S. HRG. 100-300

DEPARTMENT OF ENERGY'S FACILITIES FOR DEFENSE MATERIALS PRODUCTION

HEARING

BEFORE THE

SUBCOMMITTEE ON
ENERGY RESEARCH AND DEVELOPMENT

OF THE

COMMITTEE ON
ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

ONE HUNDREDTH CONGRESS

FIRST SESSION

ON THE

PUBLIC HEALTH AND SAFETY AND ENVIRONMENTAL ASPECTS OF OPERATION OF THE DEPARTMENT OF ENERGY'S FACILITIES FOR DEFENSE MATERIALS PRODUCTION

JULY 17, 1987

Printed for the use of the
Committee on Energy and Natural Resources

U.S. GOVERNMENT PRINTING OFFICE
78-476 WASHINGTON : 1987

For sale by the Superintendent of Documents, Congressional Sales Office
U.S. Government Printing Office, Washington, DC 20402

S. 311-15

COMMITTEE ON ENERGY AND NATURAL RESOURCES

J. BENNETT JOHNSTON, Louisiana, *Chairman*

DALE BUMPERS, Arkansas
WENDELL H. FORD, Kentucky
HOWARD M. METZENBAUM, Ohio
JOHN MELCHER, Montana
BILL BRADLEY, New Jersey
JEFF BINGAMAN, New Mexico
TIMOTHY E. WIRTH, Colorado
WYCHE FOWLER, JR., Georgia
KENT CONRAD, North Dakota

JAMES A. McCLURE, Idaho
MARK O. HATFIELD, Oregon
LOWELL P. WEICKER, JR., Connecticut
PETE V. DOMENICI, New Mexico
MALCOLM WALLOP, Wyoming
FRANK H. MURKOWSKI, Alaska
DON NICKLES, Oklahoma
CHIC HECHT, Nevada
DANIEL J. EVANS, Washington

DARYL H. OWEN, *Staff Director*
D. MICHAEL HARVEY, *Chief Counsel*
FRANK M. CUSHING, *Staff Director for the Minority*
GARY G. ELLSWORTH, *Chief Counsel for the Minority*

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

WENDELL H. FORD, Kentucky, *Chairman*
WYCHE FOWLER, JR.,Georgia, *Vice Chairman*

DALE BUMPERS, Arkansas
HOWARD M. METZENBAUM, Ohio
JOHN MELCHER, Montana

PETE V. DOMENICI, New Mexico
DANIEL J. EVANS, Washington
LOWELL P. WEICKER, JR., Connecticut
CHIC HECHT, Nevada

J. BENNETT JOHNSTON and JAMES A. McCLURE are Ex Officio Members of the Subcommittee

MARY LOUISE WAGNER, *Professional Staff Member*

CONTENTS

STATEMENTS

Page
Evans, Hon. Daniel J., a U.S. Senator from the State of Washington 35
Ford, Hon. Wendell H., a U.S. Senator from the State of Kentucky...................... 32
Hatfield, Hon. Mark O., a U.S. Senator from the State of Oregon 37
Johnston, Hon. J. Bennett., a U.S. Senator from the State of Louisiana 1
McClure, Hon. James A., a U.S. Senator from the State of Idaho......................... 30
Metzenbaum, Hon. Howard M., a U.S. Senator from the State of Ohio 40
Porter, Dr. J. Winston, Assistant Administrator, Solid Waste and Emergency Response, Environmental Protection Agency, accompanied by Lisa Friedman, Associate General Counsel; Gene Lucero, Director, Office of Waste Programs Enforcement; and Chris Grundler, Director, Federal Facilities Compliance Task Force 130
Reicher, Dan W., Attorney, Nuclear Project, Natural Resources Defense Council, accompanied by Dr. Thomas Cochran, Senior Scientist, NRDC.......... 191
Roddis, Dr. Louis H., Consulting Engineer, Charleston, SC 162
Tape, Dr. Gerald F., Consultant, Washington, DC 167
Walker, Mary L., Assistant Secretary, Environment, Safety and Health, Department of Energy, accompanied by Troy Wade, Principal Deputy Assistant Secretary, Defense Programs; Delbert Bunch, Deputy Assistant Secretary for Safety, Health and Quality Assurance; and Raymond Berube, Acting Director, Environmental Guidance and Compliance 2

APPENDIXES

APPENDIX I

Responses to additional committee questions.. 221

APPENDIX II

Additional material submitted for the record 332

DEPARTMENT OF ENERGY'S FACILITIES FOR DEFENSE MATERIALS PRODUCTION

FRIDAY, JULY 17, 1987

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The committee met, pursuant to notice, at 10:03 a.m., in room SD-366, Dirksen Senate Office Building, Hon. J. Bennett Johnston, chairman, presiding.

OPENING STATEMENT OF HON. J. BENNETT JOHNSTON, A U.S. SENATOR FROM THE STATE OF LOUISIANA

The CHAIRMAN. The hearing will come to order.

I congratulate the subcommittee for holding this hearing on environmental and safety issues at the defense production facilities of the Department of Energy.

The facilities have been in the news this year much to the discomfort of the Secretary of Energy. The Department of Energy's nuclear programs are suffering a crisis of credibility.

The N-reactor at Hanford is shut down.

Production reactors at Savannah River are operating at reduced power because of fears that the emergency cooling systems could not handle an accident at full power.

At Oak Ridge, four nuclear research reactors are shut down because of concern about the local DOE management and oversight. Embrittlement problems have resulted in the shutdown of another Oak Ridge reactor since November 1986.

Environmental and safety problems at the Fernald, Ohio, fuel fabrication plant were so severe that DOE fired its contractor at that facility.

These situations have produced severe credibility problems for DOE and for its contractors. One direct result of this in the 100th Congress has been a bitter debate over provisions proposed for the Price-Anderson Act to discipline and even to punish DOE contractors at these facilities.

So, the hearing today is timely. We know that DOE and the DOE contractors are aware of the public perception of performance.

One of the proposals we came up with during the debate on the Price-Anderson Act extension is to establish an inspector general for nuclear programs in the Department. This inspector general would be independent and free to investigate and make recommendations concerning safety and environmental issues at DOE nuclear facilities. Others have proposed a kind of safety board to oversee and review DOE activities. Still others want to subject DOE to regulations similar to the regulation of commercial nuclear power.

These ideas are there because the public is very concerned about the dangers they perceive in connection with these facilities. We will have to respond to these concerns. I hope this hearing can help us do that intelligently.

I am pleased to have as our first witness Mary L. Walker who is Assistant Secretary for the Environment, Safety and Health Programs of DOE, who is accompanied by Mr. Troy Wade, Principal Deputy Assistant Secretary for Defense Programs in the Department of Energy. Ms. Walker, we are delighted to have you.

STATEMENT OF MARY L. WALKER, ASSISTANT SECRETARY, ENVIRONMENT, SAFETY AND HEALTH, DEPARTMENT OF ENERGY, ACCOMPANIED BY TROY WADE, PRINCIPAL DEPUTY ASSISTANT SECRETARY, DEFENSE PROGRAMS; DELBERT BUNCH, DEPUTY ASSISTANT SECRETARY FOR SAFETY, HEALTH AND QUALITY ASSURANCE; AND RAYMOND BERUBE, ACTING DIRECTOR, ENVIRONMENTAL GUIDANCE AND COMPLIANCE

Ms. WALKER. Thank you, and thank you members of the committee for this opportunity to talk to you today about DOE and what Secretary Herrington is doing at the Department.

In addition to Mr. Wade, I am also accompanied to my right by Del Bunch, the Deputy Assistant Secretary for Safety, Health and Quality Assurance; and Raymond Berube, the Acting Director of the Office of Environmental Guidance and Compliance.

My prepared statement conveys the gravity of concerns that Secretary Herrington faced two years ago when he came to the Department as contrasted with today's circumstances. I will not go into all of those, but I would like to highlight a few.

His response both then and now in environmental and safety matters has been one of action. In response to a weak Environment, Safety and Health Organization, he established an Assistant Secretary and committed significant resources to that function.

In response to toothless oversight, he established a rigorous safety and environmental review system, set forth strong policies and gave me shutdown authority.

In response to Chernobyl, he initiated even further reviews both by my Office and by outside entities, including the Roddis Panel and the National Academies of Science and Engineering.

And his recent commitment to permanent nuclear safety outside oversight of DOE facilities is yet another action consistent with his desire to insure that the Department carries on its important mission but not at the expense of the environment, as in the past, and not with a lesser standard of safety than excellence.

And what are the results in 18 months? There is a changed attitude in the Department at all levels concerning safety and environmental issues. There is a strong internal oversight function. We are working closely with other agencies, the States and authorities over us to come into compliance, recognizing we are not now there. And there is a recognition, even a heightened awareness both in the Department and in the public as our reports become available of problems that still need to be addressed. And there is a recommitment to the fact that an acceptable level of safety is a precondition of operation. And this has been demonstrated in actions highlighted in my prepared testimony.

In not lowering our expectations of safety performance, even as to DOE's aging facilities, we knew some operations might have to be suspended in order to make some improvements.

This we have done. One out-fall of this, of course, has been a perception that things are worse. This could not be further from the truth. The Secretary's changes are significant and they are working. But in 18 months, you cannot completely correct 40 years.

Our critics would tell you the glass is half empty, and they would tell you all that remains to be done. I would tell you the glass is half full and tell you of our commitment to finishing the job we have started.

The Department has come a long way. We have a long way to go. A strong internal safety and environmental organization, coupled with a well-designed, permanent nuclear safety outside oversight, is a strong combination. But outside oversight or any environment, safety and health oversight will not by itself lead to effective safety performance.

The root of the current problems lies with the inherent process and the age of the facilities. These issues are not as easily addressed by better practices or management attention. We need to change the process by which we develop and apply current standards to these facilities, the manner in which we insure compliance and the way we analyze safety performance of new facilities.

These efforts will take both time and money, something Mr. Wade and the Defense Programs organization have been examining in their strategic planning efforts. From this standpoint, a decision on a new production reactor will be an important milestone in this strategy. And it is important to my organization as well since it will meet the mission's needs while satisfying the most rigorous standards of environmental and safety performance.

And my own organization is working on other measures to further institutionalize the changes Secretary Herrington began in the areas of standards and compliance. The continuation of this trend will be assured as we work together.

I look forward to that, and I also look forward to welcoming your support. I would be happy to answer any questions you have.

[The prepared statement of Ms. Walker follows:]

STATEMENT OF

MARY L. WALKER

ASSISTANT SECRETARY FOR ENVIRONMENT, SAFETY AND HEALTH

U.S. DEPARTMENT OF ENERGY

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON ENERGY AND NATURAL RESOURCES

UNITED STATES SENATE

JULY 17, 1987

Mr. Chairman, thank you for the opportunity to testify before this Subcommittee on the Department of Energy's defense nuclear facilities. Accompanying me today are Troy Wade, Principal Deputy Assistant Secretary for Defense Programs, Delbert Bunch, Deputy Assistant Secretary for Safety, Health and Quality Assurance, and Ray Berube, Acting Director, Environmental Guidance and Compliance.

These are both difficult and challenging times for the Department's Environment, Safety and Health program. The Secretary has made an acceptable level of safety assurance a precondition for operation. In simple terms, we will not allow a facility to operate unless its design, operations, and personnel practices can be demonstrated as being acceptly safe against recognized standards. This is a most conservative test, one that our older facilities have had difficulty passing. In not lowering our expectations for these facilities, we knew that some operations would have to be suspended to permit the requisite additional improvements to be made. As the record shows, and as outlined in the attached appendix, we have not hesitated to do so when circumstances warranted. However, while a necessary strategy for the short-term, we do not view this mode of ES&H compliance -- suspended and constrained operations in place of necessary facility replacement or modification -- as acceptable for the long run.

The Department is coming to grips with a legacy of past practices and aging facilities and is taking corrective action. What I want to put into perspective for you today is how far this Department has come in the past 2 years and the major steps that have been taken to bring about change.

The Secretary's ES&H Initiatives -- Actions, Not Words

Secretary Herrington came to the Department with a determination to address what he recognized as a long-deferred and, for the most part, unsurfaced issue: the environment, safety, and health performance of the Department's operations. One of his first actions as Secretary was to review the effectiveness of the Department's Environment, Safety and Health organization at the time, which was the precursor to the one I now head. He found an oversight organization with little clout, technical staff too few in number, and an oversight system founded on generic "paper" reviews, rather than first-hand inspections of field office and contractor performance. Above all, he found that environment, safety and health activities had not received sufficient line management support, a finding that pointed to a serious vulnerability in the Department's ability to meet national security and Government-sponsored research objectives.

The Secretary's response was immediate and decisive. By September 1985, he had announced a series of initiatives designed to strengthen the Department's independent Environment, Safety and Health oversight program, and to gain knowledge of the specific environmental and safety concerns at DOE sites, in order to take appropriate corrective actions and clean up what was characterized as the "legacy of the past."

As a first step, the Headquarters ES&H organization was elevated and put under the auspices of an Assistant Secretary, the position for which I was confirmed by the Senate in December 1985. Second, two innovative programs were initiated to establish a baseline of environmental and safety information across the entire DOE production and research complex -- the Environmental Survey and the Technical Safety Appraisal program. Planned in 1985 and implemented in early-1986, both of these programs are nearing their midpoints. These efforts are, as was intended, uncovering areas that need strong and immediate corrective actions.

One of the tasks of the new ES&H organization was a review of all DOE orders related to environment, safety and health. This review was completed in June 1986. As a result, we made major revisions in such key areas as quality assurance, nuclear safety, and industrial hygiene. Included in the revision of DOE directives is the shutdown authority granted to the Assistant Secretary for Environment, Safety and Health. It is now evident that further changes will be necessary to provide the detailed guidance needed to assure that all new facilities and major facilities are constructed and operated, and their site environment managed, in ways that assure good environmental and safety performance. To this end, we are developing new Departmental Orders related to radiation protection, nuclear facility design, and in environmental protection, standards and requirements for radiological monitoring, and Superfund implementation (CERCLA/SARA).

Recognizing that the prime responsibility for environmental and safety performance is vested in the line operating programs, the Secretary took the further step of issuing an Environmental Policy Statement in January 1986, and a corresponding Safety and Health Policy Statement in August 1986. These Secretarial policy statements made it unequivocally clear that good environmental and safety performance is a prime responsibility of every component of DOE and that the Department will comply not only with the letter, but with the spirit of environmental regulations and safety requirements. Most importantly, these words have been given true meaning by consistent actions on his part and that of top management to make them an important factor for all decisions involving the environmental, safety and health issues. Recent examples are the Department's response to, and corrective actions for, safety concerns raised at the Savannah River production reactors, N Reactor, and the Hanford Plutonium Finishing Plant.

Strengthened ES&H Oversight is Identifying Problems

In the past 18 months, in addition to the Environmental Survey of 16 sites and ongoing safety appraisals, my Office has conducted 16 Technical Safety Appraisals (TSAs), 7 quality assurance appraisals, and Design Reviews of N Reactor, the Savannah River production reactors, and the High Flux Isotope Reactor at the Oak Ridge National Laboratory. Several special safety reviews were also conducted to resolve specific concerns at our reactor facilities (such as reactor vessel embrittlement and confinement effectiveness). Each TSA involves a cadre of 10-15 outside technical experts who examine first-hand all aspects of the operation at the facility site. The intensive reviews performed by the Department's independent ES&H group have been supplemented by additional actions. The Secretary appointed the Roddis panel of six outside experts to review N Reactor safety; and the National Academy of Sciences and Engineering (NAS/NAE) was asked to examine the safety of the Department's Category "A" reactors. The NAS is expected to report on the Savannah River and Hanford production reactors in the next few months. We expect that the NAS will also identify other concerns and make further recommendations, which we will deal with forcefully and promptly.

I have included as an Appendix to my testimony a summary of ongoing safety enhancement and corrective actions at key facilities taken in response to concerns surfaced in the oversight process. The material in that Appendix demonstrates that the Secretary's initiatives have truly contributed to the identification of safety concerns and have guided our response consistent with the Secretary's dictum of "safety first." We would not suggest there are no problems. The point is the Department is committed to addressing those problems.

Beyond the Initiatives -- Actions to Institutionalize Change

Although substantial gains have been made in strengthening safety oversight within DOE, we know this, by itself, will not be sufficient. Stemming from the strong management support of the Secretary, these advances must now be translated into upgrades to facilities and operations, strengthened standards, additional and more intensive oversight, increased resource requirements and greater emphasis on contractor self-improvement programs. Oversight alone, of course, is not enough. The Department is faced with the dilemma of operating aging nuclear production and research facilities essential to its national security and research mission while also having made stricter adherence to safety requirements a precondition for continued operation. The recent efforts to provide such assurance through rigorous compliance action is a necessary, but interim measure. The ultimate solution for this and other fundamental issues will be to establish the programs and priorities, as well as the resources, requirements, and schedules -- and act on them without delay.

ES&H Implications of Aging Nuclear Facilities

The problem of aging nuclear facilities is one that will require a great deal of forethought, planning, and commitment by the Department, Congress, and the public in order to make the necessary decisions and provide the requisite resources to act on these long-standing circumstances. The actions outlined in the Appendix involving the shutdown or suspension of facility operations have been required, at least in part, because of this larger problem. While these actions reflect a conservative strategy of response and do not imply that these facilities cannot be operated safely, the evolution of reactor design criteria over the past 30 years pose obvious questions of adequacy that have to be addressed. Due to the age of some of these facilities, concerns have been raised over increased physical plant fragility and outmoded safety design. The Department is developing a long-range strategic plan for its defense facilities which will address safety and environmental issues as fundamental considerations, in addition to those of a programmatic nature. As the Department's chief safety officer, my firm belief is that national security and safety considerations need not conflict, even with "safety first" as a precondition.

Outside Oversight

Secretary Herrington believes there is a need for the establishment of additional outside oversight for the safety of DOE's nuclear production and research facilities. He has publicly endorsed this measure and initiated action to bring about this development. Such additional oversight would provide a continuing source of technical advice and independent policy review, the value of which has been demonstrated by the outside safety reviews and the utilization of outside consultants in our TSAs. The Secretary's position represents a landmark development in the Administration's efforts to strengthen DOE's capabilities and credibility in resolving ES&H issues. As the Under Secretary has recently testified, the Department believes that the most beneficial and practical role for such an oversight group would be to provide advice to the Secretary on where the Department is falling short, and recommendations on how to set a course for the future. We welcome such advice from strong, knowledgeable people who appreciate the need to meet our national security requirements, but who will insist that the Department take decisive action to correct any safety problems.

Strengthened Independent ES&H Program

Along with additional outside oversight, a strong internal oversight organization is necessary. The need for a strong and independent ES&H organization was recognized as one of Secretary Herrington's earliest priorities. In the past 18 months, significant strides have been made in providing increased staff and budgetary resources to support the greatly expanded oversight role assumed by my Office. The ES&H headquarters staff has grown by 65 percent, from 100 to 165 employees, and the ES&H budget has climbed 84 percent to a requested FY 1988 funding level of $70 million. We will continue to examine ES&H resource needs in the context of our guidance and oversight responsibilities.

Contractor Self-Improvement

Another important component of good safety performance is self-improvement and self-assessment safety programs, such as those sponsored by the Institute of Nuclear Power Operations (INPO). The Department firmly subscribes to the tenet of line safety responsibility and views contractor-level programs of this kind to be in keeping both with this policy and what is considered the essentials of a complete oversight program: contractor self-assessment, internal oversight by DOE, and outside oversight. To date, the Department's contractors have not had an effective institutional means to keep abreast of emerging technical safety issues, technologies, and practices, which organizations such as INPO have provided for the commercial nuclear sector. To address this issue, the Department is currently developing a Memorandum of Understanding with INPO to provide for improved information exchange and technical assistance. To complement this prospective program, the Department is also evaluating additional means of providing a range of contractor-level services and interchange comparable to that available to any commercial utility.

Safety Analysis Reviews

The Safety Analysis and Review System is a key facet of the DOE safety program that has been strengthened over the past 2 years. As part of the process by which the Department reviews, and my Office independently evaluates, the design and construction of high and selected moderate hazard facilities, it represents the most rigorous safety assessment that a facility undergoes. The Department is concerned with improving the quality of safety analyses, and has already and will continue to take steps to assure that these analyses will be comparable to standard practice for licensed facilities. My Office has initiated more intensive audits of Safety Analysis Reports (SARs) prepared by contractors and approved by Operations Office management.

We are not satisfied with the status quo. More consistency is needed in the approach DOE follows in preparing SARs and the improvement of the overall quality of the SARs. We are taking two actions at this time: updated and improved guidance is being provided by my Office and, through our comments on SARs of DOE nuclear facilities, we are providing a clear signal that better analyses must be developed and more critical reviews conducted by the Operations Offices. Additional guidance has been provided through the recently updated "Nonreactor Nuclear Facilities Standards and Criteria

Guide." We are in the process of developing more detailed guidance for analyzing natural phenomena hazards in the context of reviews of existing facilities.

We continue to explore ways to assure that our older facilities are upgraded in light of new data, plant operating experience, and evaluation of regulatory requirements. One such measure is a program similar to the "Systematic Evaluation Program" used by the Nuclear Regulatory Commission to establish an acceptable baseline for the operation of older facilities.

Adequacy of Safety Standards

In order for any oversight system to work effectively, the "rules of the road" must be clearly defined and uniformly enforced. The Department has made gains in strengthening DOE Orders, assuring their uniform enforcement through line management and the our own safety appraisal programs, and assessing their comparability with outside regulatory requirements. However, recent reviews -- our own included -- have indicated that further effort remains. One specific need that is currently being addressed is improved implementation of the internal DOE process for evaluating changes to safety requirements for application to existing DOE facilities. Recognizing the importance of this issue, I established the Office of Safety Policy in December 1986. This Office will routinely, but independently, examine the adequacy of DOE safety policies and requirements.

The Remaining Challenge

Secretary Herrington has clearly demonstrated his commitment to "safety first" in the Department by changing the course of the past and strengthening ES&H oversight and demanding the same commitment from all parts of the Department. Even with these strong measures, we recognize that we have not addressed all the issues or corrected all the problems. A number of fundamental needs remain that will have to be addressed and resolved in the years ahead. These include:

- Resolution of key safety design concerns related to DOE's aging nuclear facilities;
- The "institutionalizing" of the strengthened ES&H oversight system;
- A rigorous review of both new and existing NRC requirements to assure that we can demonstrate comparability with applicable standards;
- Improvements to our safety appraisals to assure a well-designed, comprehensive safety design review program; and
- The effective implementation of an integrated contractor self-improvement program is in the planning stages.

These and other efforts have come to represent a considerable challenge to DOE and to Congress. Continued progress to correct existing safety deficiencies and to lend permanence to the safety goals I have outlined will also entail management commitment and -- above all --time.

ENVIRONMENTAL COMPLIANCE

The Department's Environmental Policy Statement, originally issued by the Secretary in January 1986, sets forth the framework for the Department to meet its environmental obligations. Secretary Herrington states that "...protection of the environment and the public are responsibilities of paramount concern and importance ..." and the Department is firmly committed "...to assuring incorporation of national environmental protection goals in the formulation and implementation of DOE programs."

In the last 2 years, the Department has made significant progress in attaining the goals embodied in the Secretary's Environmental Policy Statement. An important indicator of this progress is the successful effort we are making in working cooperatively with the Environmental Protection Agency (EPA) and the States toward achieving full compliance with environmental requirements at DOE nuclear protection and research facilities. For example, over the last 14 months, we have entered into 12 formal written agreements with EPA and/or States on specific measures to correct deficiencies in complying with environmental requirements at DOE facilities. The latest of these agreements is the landmark "Consent Order and Compliance Agreement" we signed last week with EPA for our Idaho site.

Resource Conservation and Recovery Act (RCRA)

The Department acknowledges we have RCRA compliance problems at many of our facilities. These problems, to a large extent, developed because of the prolonged legal uncertainty regarding the applicability of RCRA to DOE activities, which are authorized under the Atomic Energy Act (AEA). The uncertainty was resolved on May 1, 1987, when DOE published a final rule in the Federal Register clarifying our obligations under RCRA. It states that DOE radioactive waste which is also hazardous waste under RCRA is subject to joint regulation under both RCRA and the AEA. We are actively working with EPA and the states to implement the new rule and to bring all affected DOE radioactive waste management facilities into full compliance with RCRA requirements. In addition, we are continuing our efforts to correct RCRA compliance problems related to hazardous wastes not associated with the new rule. For example, we have entered into nine separate, formal agreements with EPA and/or states concerning RCRA requirements. Under these agreements, DOE is installing several hundred groundwater monitoring wells, initiating closure and/or cleanup actions of hundreds of waste sites, and implementing numerous other corrective actions designed to achieve full compliance with RCRA requirements. We are currently working on several similar agreements and eventually plan to have such agreements for all DOE sites experiencing RCRA compliance problems.

We are not claiming that we have now solved all of our RCRA compliance problems. That will probably take several years, given the size and diversity of DOE's hazardous waste management activities. This effort will involve over 250 RCRA permitted or interim status treatment, storage, or disposal facilities and about 20 million tons of hazardous and mixed waste on an annual basis. However, we do believe that we are now in a position to accelerate progress and get the job done.

Superfund Amendments and Reauthorization Act (SARA)

To meet new environmental requirements, we have taken a number of actions to implement section 120 of the Superfund Amendments and Reauthorization Act (SARA) of 1986, since it was signed into law on October 17, 1986. On October 22, 1986, I sent a memorandum to all Secretarial Officers and Heads of Field Organizations announcing the enactment of SARA and detailing certain key requirements, including section 120. On March 6, 1987, we sent a copy of Executive Order 12580 implementing SARA with an accompanying guidance memorandum to all DOE offices. In addition, we held a 2-day workshop for about 75 DOE personnel in March 1987 to discuss the SARA requirements in depth. At the workshop a notebook containing guidance from the EPA and materials prepared by my staff was distributed to the attendees to assist in the implementation of the new Act.

Second, DOE has already conducted a number of investigations similar to Preliminary Assessments and Site Investigations at its facilities. Pursuant to DOE Order 5480.14, the 1985 internal directive implementing CERCLA, DOE facilities have conducted evaluations of potential sites and prepared draft reports covering about 1,000 inactive waste sites and spill and leak areas. Draft reports were completed by most DOE facilities and transmitted to the Office of Environment, Safety and Health and the appropriate Program Offices in 1986 for review. Although those reports are similar to Preliminary Assessments and Site Investigations, they are not equivalents. Recognizing that SARA requires the performance of Preliminary Assessments and Site Investigations (PA/SI), my staff has been reviewing the reports to identify the revisions that need to be made to meet the requirements of section 120.

Third, as indicated, we have initiated efforts to revise the original 1985 DOE CERCLA Order. Our goal is to revise the order in a timely fashion so that the DOE organizations implement and comply with SARA's requirements within the statutory deadlines. We have discussed our plans to revise this order with EPA and will continue to hold meetings with EPA to ensure that the new order will fully reflect the requirements of CERCLA and SARA.

Fourth, we are working closely with EPA to ensure that the SARA Federal Agency Compliance Docket contains the best available information on DOE's potential sites. We have compiled a comprehensive updated list of potential sites through a review of available information including the Phase I reports. We are submitting this list to EPA headquarters for use in developing the Docket. In addition, we have submitted to EPA copies of our draft Phase I reports for those sites which may score high enough to be included on the National Priority List (NPL). These draft reports are being submitted for informational purposes to assist EPA in developing its NPL scoring strategy for Federal facilities.

In addition to these activities, we have initiated or participated in other interactions with EPA headquarters to encourage the exchange of information and to assist us in developing a consistent SARA program for DOE. We have met with representatives of EPA's SARA program and enforcement offices to discuss EPA's NPL scoring process, the SARA Federal Agency Compliance Docket, and to describe for EPA our current CERCLA/SARA activities. We invited an EPA representative to present to DOE Headquarters in April 1987 a PA/SI overview session in order that DOE might become familiar with the specific PA/SI requirements. Several DOE representatives also attended a PA/SI training workshop given by EPA headquarters in April. We also plan to invite EPA representatives to come to DOE to present training sessions on Remedial Investigation/Feasibility Study (RI/FS) and remedial action requirements.

In addition to the above activities, I would like to update you on the progress that DOE has made in addressing the three DOE sites which have already been proposed for the NPL. These sites are the Rocky Flats Plant in Colorado, the Weldon Spring site in Missouri (not originally a DOE site), and the Lawrence Livermore National Laboratory in California. The work underway at all of these sites was initiated prior to the enactment of SARA. At our Rocky Flats Plant, in July 1986, DOE, the State of Colorado, and EPA entered into an enforceable compliance agreement that established commitments by DOE to characterize all hazardous and radioactive mixed waste sites and to undertake necessary remedial actions. The agreement includes schedules for the technical work to be done by DOE. DOE has met all schedule deadlines to date. Site characterizations and cleanups will be conducted consistent with CERCLA, SARA, and RCRA requirements.

At the Weldon Spring Site in Missouri, DOE is conducting a comprehensive RI/FS under the oversight of EPA Region VII. The RI/FS is proceeding under a schedule and technical plan established in a Federal Facilities Compliance Agreement signed between DOE and EPA in August 1986.

At the LLNL site, our San Francisco Operations Office is working with EPA Region IX to negotiate a Federal Facilities Compliance Agreement/Interagency Agreement (IAG). The IAG, one of the first under the Act, will incorporate the elements necessary to meet the requirements of SARA, section 120. It will ensure that the remedial actions at LLNL are conducted consistent with the requirements of CERCLA and SARA. We view this as a very important and significant agreement because it will be our first SARA IAG and may serve as a model for future similar agreements.

CONCLUSION

Secretary Herrington's initiatives, his mandate for excellence in safety and environmental performance, and the changes made to date have had a "major impact" on the Department and its contractors. This is because so much has been required in these last 2 years. However, as with all such undertakings, the challenge will be to make it last -- to assure that safety and environmental excellence once again is an integral part of the Department's operational activities. I can assure you that the Secretary, I and the other senior managers of the Department are committed to establishing credibility by our actions and the legacy of change we leave behind. The Department's mission is too important to the country to accept less than excellence. We will achieve that goal.

I want to thank you, Mr. Chairman, and the members of the Subcommittee for your attention and would be pleased to answer any questions.

Appendix 1

DOE Response to Nuclear Facility Safety Findings

N Reactor. Immediately following the Chernobyl accident, Secretary Herrington requested that my Office address potential implications to N Reactor through the acceleration of the Technical Safety Appraisal already planned for that reactor, and special reviews of the reactor's overall design, confinement system, and graphite growth. He also appointed the Roddis group to evaluate these issues and commissioned a special, longer term review, by the National Academy of Sciences. The N Reactor is not like Chernobyl. It has a record of more than 20 years of accident free operation. Many improvements have been made to the reactor since it began operation. However, the reviews revealed a number of areas in which improvement needed to be made. Some reviewers concluded that the departures from requirements for licensed reactors were of such a nature that the reactor should be shut down absent a compelling need for the facility to meet defense production requirements.

After the Department reviewed all the comments received, an aggressive course of correction was developed and programs are now underway to make further improvements to the plant and to the operations. The National Academy of Sciences has been requested to review the recommended approach towards hydrogen mitigation, and may offer additional recommendations when it releases its interim report on the N Reactor and Savannah River production reactors.

Savannah River Production Reactors. The Savannah River reactors have also been intensively reviewed since Chernobyl. There have been reviews of the fire protection systems, quality assurance programs, a Design Review, a Technical Safety Appraisal, reviews by GAO and by the National Academy of Sciences. The Savannah River Operations Office and the contractor, DuPont, has prepared an integrated response on how the contractor will implement the recommendations made by my Office. We are now reviewing that response.

The report of the NAS review has not yet been completed, but we expect that many of the concerns identified by earlier reviews will also be raised by the NAS, and new issues will probably surface that need to be acted on. The NAS has advised the Department of the NAS concerns about the emergency core cooling system for the Savannah River reactors.

As with licensed reactors, the Savannah River reactors rely on special systems to keep the core cool in the event of a failure in the routine cooling systems. Questions regarding the adequacy of these emergency core cooling systems (ECCS) finally led DuPont to conclude that safety margins were not as great as they should have been. In order to assure adequate cooling capacity, reactor power levels were reduced. The National Academy of Sciences, during the course of their review of the safety of DOE's Class "A" production and research reactors, raised substantial additional concerns that resulted in the Department taking immediate action to further reduce the power level to assure that the safety systems would function as intended, even under very unlikely accident scenarios. A special EH led team of experts has since reviewed the methodology used by Savannah River in meeting the imposed power criterion and found it to be acceptable. Actions are underway to develop the necessary technical data and to make needed hardware changes. No increase in power will be undertaken until such time that it can be convincingly demonstrated that emergency core cooling systems will work as intended under the full range of design basis accident conditions.

High Flux Isotope Reactor (HFIR). The operating safety limits for HFIR were approved by the Atomic Energy Commission in 1965 and included a surveillance program to evaluate the extent of radiation-induced embrittlement over the life of the reactor. HFIR was shut down in November 1986 following a determination by the Oak Ridge Operations Office (ORO) and a review by my Office concluding that the surveillance program had not been performed adequately and the technical basis supporting a key operating limit was no longer valid. This unprecedented action -- shutting down a facility due to non-compliance with technical specifications and surveillance requirements -- stems directly from the Secretary's initiatives in oversight and his expectation that line management exercise their prime responsibility for ES&H in a positive manner. A subsequent investigation by ORO identified a broad range of needed actions ranging from improvements to the surveillance program to better oversight by DOE and the contractor. Until all concerns surrounding the management of safety assurance at HFIR, all safety concerns raised during the course of our subsequent investigations, and the specific issue of pressure vessel embrittlement are resolved, HFIR will not be permitted to restart. We anticipate a program commitment to resolve the management issues by next month with an analysis of the embrittlement issues within several months.

Oak Ridge Research Reactors. The issues surrounding the HFIR incident raised concerns that similar problems might exist at other facilities. My Office conducted an independent review of the safety management, quality assurance, and safety oversight program at the Oak Ridge National Laboratory. This review confirmed the existence of deficiencies in the contractor and DOE oversight and safety management of remaining reactors at Oak Ridge. In response, the Manager of the Oak Ridge Operations Office ordered, as a precaution, the suspension of all operations at the other Oak Ridge reactors (Oak Ridge Research Reactor, Bulk Shielding Reactor, Health Physics Reactor, and the Tower Shielding Facility). Steps are now being taken by my Office, the program offices, Oak Ridge Operations Office, and the contractor, to strengthen the oversight system and reverse this situation. These reactors will not resume operation until institutional changes have been made and programs are in place to assure full compliance with DOE requirements and full cognizance by all levels of management of safety oversight responsibilities.

PUREX/Plutonium Finishing Plant. Acting on concerns surrounding violations of procedures, particularly those for criticality and quality assurance, the Department's Richland Operations Office (RL) Manager suspended operations at the PUREX plutonium extraction plant and the Plutonium Finishing Plant (PFP) in October 1986. To resolve the root causes of the observed problems, the contractor was directed to undertake a number of activities, including retraining of plant operators, improved management commitment and attention to enforcing procedures, and strengthened safety oversight. To assure that all actions were complete and satisfactory, the Operations Office performed a Readiness Review of all pertinent aspects of the safety programs at PUREX and PFP. My Office independently reviewed the results of this review and other actions undertaken by the contractor prior to startup of PUREX in March 1987. During the course of the Department's review of the seismic qualification of PFP, it was evident that the facility could be vulnerable to collapse in the event of a strong earthquake, and that an adequate safety analysis review had not been performed to assure that worker and public safety risks had been properly mitigated. Additional analyses of the plant are now being conducted and until their results confirm an acceptable margin of safety, DOE has chosen to keep portions of PFP shut down, except for recycling of a small quantity of existing plutonium scrap that needs to be processed for safety reasons.

Exemplary Operations Exist

The Fast Flux Test Reactor (FFTF) at Hanford, the Pantex weapons fabrication plant in Texas; and the TA-55 plutonium facility at Los Alamos, New Mexico have all been reviewed as part of the TSA program and found to be good models of the commitment to safety that we want to see in all of our operations. These relatively new facilities have both undergone intensive, independent safety reviews before operations commenced. The TSA teams found these operations are based on a strong commitment to safety, and deficiencies found in our appraisals were limited to largely procedural items. Other recently constructed DOE nuclear facilities, as well as those under construction, have been designed and constructed during the era of strict, and very prescriptive safety regulation. They meet not only licensed requirements, but represent safety models from which the NRC and the industry have drawn safety standards and experiences.

The CHAIRMAN. I have a statement here from Senators McClure and Hatfield which we will put in the record.

Senator FORD. Mr. Chairman, I also have a statement I would like to have included in the record.

The CHAIRMAN. Without objection.

Senator EVANS. I also have a statement.

The CHAIRMAN. Without objection.

[The prepared statements of Senators McClure, Ford, Evans, Hatfield, and Metzenbaum follow:]

OPENING STATEMENT OF SENATOR JAMES A. McCLURE

JULY 17, 1987 HEARING

Good morning. I am pleased that the Energy Research and Development Subcommittee has scheduled this hearing to investigate safety and environmental issues at DOE's defense production facilities.

I am aware of the particular interests of Senator Evans and Senator Hatfield concerning future operation of the N-reactor at Hanford, Washington, especially in light of safety questions that have been raised since the Chernobyl accident last year. I remind my friends of the hearings this Committee held immediately after that unfortunate accident in Russia, and the conclusions of that hearing and of studies done subsequently, that a Chernobyl-type accident simply cannot occur in the United States, because of the differences in design and operating philosophy between U.S. and Russian reactors.

Nevertheless, there are ligitimate safety concerns that *have* been identified by the National Academy of Sciences and other experts that have since examined in detail the operations of N-reactor and the Savannah River reactors. These examinations have verified what I have been predicting for years, and that is: these reactors are aging, they have a finite lifetime, and, while they can be operated safely, the design of these reactors does not meet today's safety standards. Thus, it is invevitable that these machines, as well as *other* equally-aged and out-dated facilities, must be replaced by modern facilities, and that planning and budgeting for these new facilities probably should have started 5 years ago, but certainly must not be delayed any longer. Furthermore, we should not look upon this a curse, but

RATHER AS A UNIQUE OPPORTUNITY TO DRAW FROM OUR MOST ADVANCED STATE-OF-THE-ART TECHNOLOGIES SO THAT HOPEFULLY, WITHIN 10 YEARS, WE WILL BE ABLE TO OPEN THE DOOR ON THE SAFEST, MOST ENVIRONMENTALLY BENIGN REACTORS THAT THIS COUNTRY HAS EVER BUILT FOR ANY PURPOSES. I, FOR ONE, AM PREPARED TO ACCEPT THIS CHALLENGE, AND OFFER TO THE DEPARTMENT ANY ASSISTANCE THAT THEY MIGHT NEED TO MOVE THIS EFFORT FORWARD.

BEFORE I FINISH, I WOULD LIKE TO MAKE ONE MORE POINT THAT MAY OTHERWISE BE LEFT UNDERSTATED THROUGH THE COURSE OF THIS HEARING. I AM VERY MUCH AWARE OF AND VERY CONCERNED ABOUT NOT ONLY THE SAFETY PROBLEMS, BUT ALSO THE MAJOR ENVIONMENTAL LEGACIES THAT MUST BE DEALT WITH IN ORDER FOR THE DEPARTMENT TO CONTINUE TO CARRY OUT ITS DUTIES IN AN ENVIRONMENTALLY ACCEPTABLE MANNER. MY OWN STATE OF IDAHO IS NO MORE INSULATED FROM THESE PROBLEMS THAN OTHER STATES THAT HOST THE DEPARTMENT'S FACILITIES AND LABORATORIES. BUT ONE THING IS PERFECTLY CLEAR TO ME, AND THAT IS THE FACT THAT, WHILE THE NECESSARY REMEDIAL ACTIONS ARE CARRIED OUT, AND WHILE NEW FACILITIES ARE BUILT TO REPLACE OLDER FACILITIES, THE DEPARTMENT'S ACTIVITIES WITH RESPECT TO MATERIALS PRODUCTION AND NUCLEAR WEAPONS RESEARCH AND PRODUCTION MUST GO FORWARD UNIMPEDED; THAT THIS NATION'S NATIONAL SECURITY IS PARAMOUNT; AND THAT NUCLEAR ARMS CONTROL TREATIES MUST NEVER BE PREDETERMINED BY OUR OWN SHORTSIGHTED DECISIONS. MY POINT IS THAT WE MUST NOT MAKE OUR DECISIONS WITH RESPECT TO THE FUTURE OF OUR WEAPONS COMPLEX IN A VACUUM; WE MUST WEIGH THE SAFETY AND ENVIORNMENTAL GOALS AGAINST THE VERY SECURITY OF OUR NATION AS A WHOLE. AND WITH THAT BALANCE IN MIND, I HAVE NO DOUBT THAT ULTIMATELY WE WILL ACHIEVE BOTH GOALS.

STATEMENT OF SENATOR WENDELL H. FORD

HEARING ON DOE DEFENSE PRODUCTION FACILITIES

JULY 17, 1987

TODAY THE SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT IS HOLDING A HEARING ON ENVIRONMENTAL AND SAFETY ISSUES AT THE DEFENSE PRODUCTION FACILITIES OF THE DEPARTMENT OF ENERGY.

THESE FACILITIES PRODUCE THE MATERIALS FOR NUCLEAR WEAPONS. IN THE UNITED STATES, WE HAVE CIVILIAN CONTROL OF NUCLEAR WEAPONS. THEREFORE IT IS THE DEPARTMENT OF ENERGY, AND NOT THE DEPARTMENT OF DEFENSE, THAT OPERATES THE FACILITIES OF THE NUCLEAR WEAPONS PROGRAM.

WE ARE FACING A CRISIS IN THIS PROGRAM.

- THE FACILITIES FOR THE COMPLEX ARE OLD AND NEED TO BE REPLACED. THE REPLACEMENT COST WILL BE IN THE BILLIONS.
- THE MANAGEMENT PRACTICES AT THESE FACILITIES WOULD NOT BE ACCEPTED BY TODAY'S REGULATORS. BUT REGULATION OF DOE FACILITIES IS BEING PROPOSED.
- THERE IS A LEGACY OF ENVIRONMENTAL CONTAMINATION AT THESE FACILITIES THAT WILL COST BILLIONS TO CLEAN UP.

O THE CHERNOBYL ACCIDENT HAS MADE THE PUBLIC VERY SUSPICIOUS OF THESE FACILITIES. DOE'S CREDIBILITY IS UNDER SEVERE CHALLENGE.

YET WE ARE NOT ABOUT TO STOP THE WEAPONS PROGRAM. THE PRODUCTION OF THESE MATERIALS - PLUTONIUM AND TRITIUM - WILL CONTINUE. THE QUESTION IS HOW TO CARRY OUT THESE ACTIVITIES IN A WAY THAT IS SAFE AND ACCEPTABLE AS IT RELATES TO THE ENVIRONMENT. THE QUESTION IS HOW TO RESTORE PUBLIC CREDIBILITY. THAT IS WHAT WE ARE HERE TO DISCUSS TODAY.

THE DEPARTMENT DESERVES CREDIT FOR ITS EFFORTS SO FAR TO FACE UP TO THESE PROBLEMS.

DOE HAS INSTITUTED A THOROUGH REVIEW OF ITS SAFETY PROGRAMS AND IS IN THE MIDST OF A DETAILED ASSESSMENT OF THE ENVIRONMENTAL PROBLEMS AT ITS DEFENSE FACILITIES.

AFTER THE CHERNOBYL ACCIDENT THE DEPARTMENT COMMISSIONED INDEPENDENT REVIEWS OF ITS PRODUCTION REACTORS, AND, ON RECOMMENDATION OF ONE OF THESE REVIEWS, DOE SHUT DOWN THE N-REACTOR AT HANFORD. THE N-REACTOR IS STILL SHUT DOWN.

THE DEPARTMENT RECENTLY AGREED TO BRING ITS WASTE MANAGEMENT PRACTICES UNDER ENVIRONMENTAL PROTECTION AGENCY REGULATION UNDER THE RESOURCE RECOVERY AND CONSERVATION ACT. EPA AND DOE ARE NOW

NEGOTIATING COMPLIANCE AT FACILITIES THAT LONG PREDATE THE EPA AND ITS ENVIRONMENTAL REGULATIONS.

DOE'S ACTIVITIES HAVE BROUGHT MANY OF THESE PROBLEMS TO THE ATTENTION OF THE MEDIA AND GENERAL PUBLIC. IRONICALLY, THIS HAS INCREASED, RATHER THAN DECREASED, CRITICISM OF DOE. THIS NEW FOCUS ON THE DOE WEAPONS COMPLEX HAS BROUGHT TELEVISION COVERAGE AND ARTICLES IN NEWSPAPERS AND IN MAGAZINES. MOST OF THIS COVERAGE HAS BEEN CRITICAL. AS A RESULT, THERE HAS BEEN A GROWING FEELING THAT INDEPENDENT OVERSIGHT AND, PERHAPS, REGULATION OF DOE IS NEEDED.

WE UNDERSTAND. TODAY WE'D LIKE TO GET A OVERVIEW OF THE PROBLEMS DOE FACES AND THE WAY THESE PROBLEMS ARE BEING DEALT WITH. DOE WITNESSES WILL HAVE A CHANCE TO TELL YOUR SIDE OF THINGS. I HOPE ALL OF OUR WITNESSES TODAY WILL ALSO GIVE US THE BENEFIT OF YOUR THINKING ABOUT WHERE WE GO FROM HERE.

Statement of Senator Daniel J. Evans

Oversight Hearing on the Department of Energy Defense Materials Production Reactors

July 17, 1987

Mr. Chairman, I want to express my appreciation for your cooperation in scheduling these hearings on the Department of Energy's defense materials production reactors.

Since the 1940's, the Hanford Reservation in my state has been an vital part of our nation's defense effort. I am proud of the contributions that Hanford workers have made over the years, and the service they continue to provide to the nation.

Yet in those early years of the nuclear defense program, first priorities were given to production, and environmental concerns were secondary. Certainly, with the pressure to defeat the Nazis in the race to develop the atomic bomb, such an attitude was to be expected, but it is also clear that we simply cannot subscribe to the same attitude today..

I first became aware of the serious environmental problems at Hanford in the early 1970's when I was serving as Governor. At that time, it was discovered that several underground single-shell tanks containing liquid high-level radioactive waste were leaking into the surrounding soil. Today, nearly 15 years later, very little has been done to correct the situation. While much of the liquid in the problem tanks has been transferred to newer, double-wall tanks, we still have not done anything to convert these wastes into a safer, more stable form. While action has been taken at the Savannah River Plant to develop and construct a vitrification facility to "glassify" the liquid defense wastes there, activity at the Hanford site has lagged far behind. I have raised this issue on a number of occasions with the Chairman of the full Committee, Senator Johnston, I will do my utmost to ensure that the necessary funds required to accelerate these efforts can be found in the appropriations process.

In addition to the issue of the defense wastes now being stored in underground tanks, there are a number of other serious environmental concerns which have come to public attention in recent years. Most recently, I have become extremely interested in reports of groundwater contamination at the Reservation. These problems are not only confined to radioactive contamination, but also a variety of toxic chemicals have been detected in the unconfined aquifer below Hanford. In addition to serious problems with Iodine-129 and other radioactive isotopes, hazardous materials such as nitrates have been found in the groundwater. I am also extremely concerned over very recent reports that such contaminants have travelled to the other side of the Columbia River, and may eventually cause problems outside the boundaries of the Reservation.

Just as we hold industry responsible for environmental problems resulting from manufacturing and industrial processes through the Superfund law, the federal government must respond to the environmental problems which have resulted as a consequence of our national defense program. Electric consumers bear the costs of environmental mitigation efforts at coal generating plants, so too must we adopt an an attitude in Congress which places environmental protection on the same level as the need for a strong national defense. Certainly, as we begin to clean up the wastes left by the last forty years of our defense materials production cycle, we should ensure that any new production reactors are designed and constructed with the highest regard for safety to both the public and the environment. Protecting the health of our citizens, the purity of our water and the maintenance of our biosphere is as an important part of national defense as a strong and effective military force.

-30-

Committee on Energy and Natural Resources

OPENING STATEMENT
SENATOR MARK O. HATFIELD
JULY 17, 1987

First, let me compliment the Chairman of the Committee for holding this hearing on public health, safety, and environmental issues at the DOE's defense production facilities. It is clear from every quarter that there are serious problems at our aging production facilities and that these hazardous conditions are deteriorating, posing increased risks to the public and the environment.

I want to call my colleagues attention to the testimony of Mr. Reicher and Dr. Cochran of the Natural Resources Defense Council. This public interest group has worked tirelessly to uncover and address in a constructive way the serious conditions at the DOE weapons complex. I look forward to their testimony and to hearing from the other witnesses today.

A number of House and Senate Committees have completed hearings recently on safety and environmental issues at the production complex. The Department of Energy has initiated comprehensive environmental surveys and safety appraisals at these facilities. A number of scientific panels, including the National Academy of Sciences, are conducting reviews on safety and environmental problems at the reactors and other production facilities. In addition, the General Accounting Office (GAO) has issued 6 reports over the last 2 years on environmental issues and problems within the defense weapons complex. All of these oversight and review efforts have indicated serious problems at the production complex. GAO sums up by indicating that DOE's operations "do not fully comply with environmental laws. . . because DOE has not given sufficient emphasis to environmental protections at its facilities."

All this analysis and technical data, I believe, leads to the inescapable conclusion that time for further review has passed. It is now time to take decisive action.

Mr. Chairman, as you know, I am gravely concerned about the Department's decision to renovate and restart the Hanford N Reactor. Given the significant safety and environmental problems which will remain even after the planned $200 million worth of plant modifications, I believe we should shut down the facility permanently. At the very least, an Environmental Impact Statement (EIS) is the necessary and proper vehicle for consideration of this and other alternatives to continued operation of the N Reactor.

As I understand it, the Department plans to prepare an EIS of very limited scope on the so-called Safety Enhancement Program at the "N" reactor. While preparing the EIS, the Department intends to proceed with the restart of the reactor this fall before completion of the repairs and before completion of the limited

EIS. This approach is a totally empty exercise which clearly violates the spirit, if not the letter, of our environmental laws. This proposal is clearly not a legitimate review of reasonable alternatives to continued operation of the "N" reactor. Furthermore, it does not make sense to conduct such a review while the reactor is in operation.

An EIS never has been prepared for the "N" Reactor. It would serve a number of purposes. First, it would review the wisdom of spending nearly $200 million on a plant which has already exceeded its designed useful life. Second, an EIS should explore alternatives to the renovation and restart of the "N" Reactor including permanent shutdown, reliance on existing plutonium stockpiles, accelerated scrap recovery, increased retirement and recycling of material from obsolete warheads, and other options. Third, it would formally involve state agencies and the public in decision making from which they have been entirely excluded. Finally, an EIS would shore up DOE's public credibility which is at an all-time low as a result of a disturbing series of problems at Hanford and other facilities.

For all these reasons I have joined in the lawsuit to force the DOE to prepare a full EIS on the decision to resume operation of the Hanford N Reactor.

U.S. Senator Howard M.
METZENBAUM
of Ohio

Committees:
Judiciary
Labor and Human Resources
Energy and Natural Resources
Select Committee on Intelligence

Chairmanships:
Subcommittee on Antitrust
Subcommittee on Labor
Subcommittee on Energy
Regulation and Conservation

STATEMENT BY SENATOR HOWARD M. METZENBAUM
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
JULY 17, 1987

I am pleased that this hearing has been called to address the very important issues of public health and safety at the Department of Energy's defense production facilities, as well as related environmental issues. This subject is of particular concern to me and to Ohioans who reside near the Fernald feed materials production facility, which is 18 miles northwest of Cincinnati.

A number of extremely serious concerns have been raised about the health and safety of both employees at the facility and nearby residents. In fact, an ABC News Close-Up aired this past April publicized allegations that DOE and Westinghouse have not given adequate consideration to either worker safety or environmental hazards. These allegations heightened the public fears and concerns about the safety of this federal facility.

In June of 1986, I visited the Fernald facility and immediately called on DOE to take immediate action to deal with serious health and safety problems at Fernald. It is crucial to correct all existing safety and environmental problems, and that steps be taken to prevent any future hazards. We must be sure that the increased production of materials for our nation's defense does not occur at the expense of the health and safety of millions of people.

Public health and safety must be our first priority, and the government must act responsibly to instill public trust in its activities. I look forward to hearing the testimony from the various witnesses.

The CHAIRMAN. Ms. Walker, why shouldn't DOE operations just be made subject to regulation by the Nuclear Regulatory Commission?

Ms. WALKER. Well, that was one of the options that we have looked at. Whether ultimately that would be appropriate is not clear. It is clear, and what we can say about it now, is that they have more uniform facilities in the commercial reactors. DOE has a widely varying, diverse range of facilities. I believe the NRC people have told us informally—I believe they have even indicated in testimony—that they do not now have the ability to take on the Department's facilities. They are not geared up to handle the wide-ranging, diverse kinds of facilities that we have.

One of the suggestions we have made in our nuclear safety oversight—and as I would indicate to you, the Department is right now working on legislation that we believe would be appropriate in establishing a permanent outside oversight group. We would propose that a board be established which would be nominated by the President and confirmed by the Senate, and that that board would oversee our facilities for a period of time. At the end of that period of time, in addition to other functions they would have, they would provide a recommendation on the continuation, termination or transition to another perhaps permanent, more regulatory oversight body, which at that time might be appropriately that.

The CHAIRMAN. When you say oversee your facilities, what do you mean? You mean for purposes of safety and health, or for the purpose of management?

Ms. WALKER. What we have been discussing with members of Congress and hope in the very near future to present in a more formal written form, would be a board that would oversee both defense and non-defense DOE facilities, including hazardous waste storage, but not the radioactive waste facility, naval reactors, and weapons testing, that would work together with the strong internal oversight organization the Secretary has established. This board would have a broad charter so that they could look at not only specific facilities, if that was appropriate, but also that they would examine the standards, the orders, the policies that the Department follows, review them to see what improvements could be made, what should be appropriate in terms of the standards specifically with respect to the aging facilities complex because as you know, even commercial reactors of an older vintage do not meet in all cases current standards. You have to decide what is appropriate in terms of holding the older, earlier facilities accountable to standards that have been evolving over time.

The CHAIRMAN. Now, you are not talking about management. You are talking about safety and environmental oversight.

Ms. WALKER. Yes. I am sorry. I am talking about specifically nuclear safety oversight. We are basically not self-regulating in the area of environmental matters now that we have agreed with EPA that whenever we have waste that is contaminated with hazardous components as well as radioactive components, there will be joint regulation under RCRA and the AEA. EPA basically in the states will be looking at all of our facilities in the environmental area, and basically were with that exception in any event. So, yes, this board would be specifically addressing the nuclear safety oversight issue.

The **Chairman**. Do you propose that this be subject to all of the sunshine laws, such as the Nuclear Regulatory Commission? And I would suggest to you that——

Ms. **Walker**. Yes, it would.

The **Chairman** [continuing]. That while sunshine is a good thing, it has certainly made it difficult for the Nuclear Regulatory Commission to just function simply because one commissioner cannot talk to another one without calling a meeting and getting in the court reporter. I mean, they just cannot communicate. They cannot move. They cannot deal. Do you propose the same thing? Or do you have an exemption from that, or do you think that works?

Ms. **Walker**. In the provisions that we are looking at now, we would have full public accountability built into the process whereby the public would be a part of this process.

Now, the specific details of these things are being worked out. It is my understanding the sunshine laws would be applicable. And obviously you raise valid concerns, and those are being considered along with others before the proposal will be made final and offered to Congress.

The **Chairman**. I have some more questions, but I will submit them in writing.

Senator Hecht?

Senator **Hecht**. No questions at this time. Thank you.

The **Chairman**. Senator Ford?

Senator **Ford**. Thank you, Mr. Chairman.

One point I think we need to make clear here today is that the facilities that we are talking about produce the materials for nuclear weapons. And here in this country we have civilian control over the military. And therefore, it is the Department of Energy and not the Department of Defense that operates the facilities of the nuclear weapons program. I think that ought to be made abundantly clear so we will understand why the Department of Energy has this arena.

In this Senator's opinion, we are facing a crisis in the program. And you may not think so, but I certainly do. The facilities for the complex are old and need to be replaced. And I think you understand that well in what you are proposing. But the replacement cost will be in the billions of dollars.

The management practices, as I think you have stated, at these facilities would not be accepted by today's regulators. But regulation of DOE facilities is being proposed.

Now, there is a legacy I think, if I can use that term, of environmental contamination at these facilities that will again cost billions of dollars to clean up. The Chernobyl accident has made the public very suspicious of these facilities, and has strained I think with the best of efforts the credibility of DOE under this challenge. The Department, however, in my opinion deserves credit, credit for its efforts so far to face up to the problem as they see it.

What we are trying to do today is get to a point that after the Chernobyl accident, the Department get into its review. DOE instituted a commission to make the reviews of its production reactors, and on recommendation of these reviews, DOE shut down the N-reactor at Hanford. So, I want to get to that, and it is still down. So, let me get to that one.

Why is it, as I understand it, that DOE thinks that the N-reactor should be restarted when members of your review panel recommended that it be shut down permanently?

Ms. Walker. Well, if I could go over some of the reviews we conducted, I think it might put this in proper perspective.

After Chernobyl occurred, the Secretary accelerated the technical safety review that my office had scheduled for that so that it was going——

Senator Ford. Shouldn't we make a point that this is similar to the Chernobyl plant?

Ms. Walker. Well, I think we have to say that with the exception of the fact that they both have graphite moderators, they are very dissimilar.

Senator Ford. OK.

Ms. Walker. I think it is important to recognize that. In fact——

Senator Ford. But they are similar in that respect.

Ms. Walker. Right, in that respect.

We conducted, in addition to the technical safety appraisal, a design review, a special safety review looking at the graphite issue, the confinement issue, fire protection issues raised by Chernobyl, and in addition to all these reviews performed a cumulative analysis taking all of those reviews together. Now, this is my office, but at the same time these three different review teams—actually four including quality assurance—were primarily composed of outside experts. Some 30 plus outside experts were working for my organization in reviewing the N-reactor from top to bottom after Chernobyl.

In addition to that, of course, the six independent Roddis experts were convened to look specifically at the N-reactor and its safety in light of Chernobyl. All of my 30 plus experts advising me told me the reactor did not pose an unacceptable risk. In addition, four out of the six Roddis experts confirmed that. Two of the Roddis experts felt that if there was not a need for the reactor, it should be shut down because it did pose higher risks than commercial reactors. But even they said if you find a need for the reactor—that is, if there is a finding of a need for this reactor for the national defense—they would find its operations acceptable if the improvements that were made—recommended by my safety reviews were made, and then some others that they had indicated.

We have in a very real sense then not only looked seriously at all of these issues and realized that the reactor did not pose an unacceptable risk, but in agreeing to make all these safety improvements, we have even complied with the minority that would have said if there was no need, shut it down. So, I think that the overwhelming body of expertise that looked at the reactor has concluded it does not now pose an unacceptable risk. And therefore, we felt even in the most conservative way, we could be content to see it operate.

I asked the Under Secretary to put the reactor in an extended outage to accelerate some of these safety improvements, but even that was not considered mandatory and that was almost a personal recommendation of my own. My own experts did not insist on that, but I felt it appropriate and, therefore, asked them to do that, and that was approved. And it is being done at this very time.

Senator **Ford**. Madam Secretary, give us some insight as how did the N-reactor come to be in such sorry shape?

Ms. **Walker**. Well, I will give you my opinion, and then I will let Mr. Wade, who has a much longer history with the organization than I do, and Mr. Bunch, who has expertise and has been with the NRC, give you some flavor for it.

Senator **Ford**. That would be sorry, sorry, and sorrier.

Ms. **Walker**. Perhaps.

It is my impression that you have an older facility built in the 1960s that although many upgrades have been made—and I could give you a list of the upgrades that have been made to that facility. It has not just been allowed to sit there and age. But you have a facility that even though upgraded will never be like the new facilities. It is an older technology.

And although it has had a 23-year operating history without incident or unplanned accidents, I think you basically have a facility that is nearing the end of its life.

And you also have perhaps some complacency borne out of a good safety record. If you do something right for 23 years, I think you begin to think maybe you cannot make the mistakes that other people want you to be aware you can make. And so, one of the things Secretary Herrington has done is to say to everybody we will not tolerate complacency even borne out of a good record. We will change that attitude. And that has been done.

But let me allow Mr. Wade and Mr. Bunch to contribute here because I am, as you know, fairly new with the agency.

Mr. **Wade**. Senator Ford, I would add only that while it is a very old reactor, it has been operated safely. And as Assistant Secretary Walker just said, no one believed it was in sorry condition. We have agreed that it was safe, but we would increase the margin of safety, and the accelerated safety enhancement program was designed to do precisely that.

Senator **Ford**. Was that before Chernobyl or after?

Mr. **Wade**. The enhancements that are being installed now are post Chernobyl.

Mr. **Bunch**. Senator Ford, one final observation. I think it is also fair to say that if you were to compare the kind of improvements that have been made at N-reactor over time up to Chernobyl, you would not see the same type and extent of improvements as you would see with the comparably aged, licensed facilities. Part of the reasons why we have undertaken the acceleration of improvements is basically to move in a direction of making this facility more comparable to what you might expect with a licensed facility that is of the same age.

Senator **Ford**. Madam Secretary, I think you said—and this will be my last question, Mr. Chairman, and I will submit some other questions for the record. You said that your 30 or so experts advised you that you could start up the N-reactor if it was needed to be put into place.

The question in my mind I think from that statement—and it bothers me just a little bit—is what is the tradeoff in safety in restarting the reactor. What kind of tradeoff do you have, if any?

Ms. **Walker**. Let me just say first, a point of clarification. The 30 plus experts advising me that functioned on these review teams of my office found that the continued operation of the reactor—remember, it had not been shut down. The continued operation of the reactor did not pose an unacceptable risk. They did not raise the issue of whether the reactor was needed. The only time that issue was raised was by a few members of the Roddis panel that said if you find the reactor is needed for national security, then we feel operations can continue. Again, the reactor had not been shut down. It can continue if you make these safety improvements.

And they were the ones who raised that. And the Under Secretary and the senior management on the program side of the Department did review that and concluded the reactor was needed.

Even if it had been needed, if it posed an unacceptable risk, I would have shut it down. But having already concluded it did not pose an unacceptable risk, obviously the reactor could be allowed to continue.

Now, let me just say so that the whole shutdown and restart issue is clear, the reactor was put in a stand-down condition or its regular maintenance outage was extended to accelerate some of these safety improvements. That was not recommended by anybody but me. Even my own experts did not recommend that the reactor be brought down to do that. That was something that I and my senior deputies felt was really the most conservative thing, but albeit something in light of Chernobyl and public concern and everything else really would be the appropriate thing to do. So, we recommended that and it was done.

But the issue of whether the reactor was safe to restart was never the issue because the reactor was a continuing reactor. I mean, it was continuing operations. And the issue was whether it could continue to operate. Did it pose an unacceptable risk? And the answer was no. Even the Roddis panel felt that if these safety improvements were made, they felt comfortable with that.

Senator **Ford**. Fine. Thank you, Mr. Chairman. I have no further questions. But I do have some for the record and hope that they will be answered expeditiously.

The **Chairman**. Senator Evans?

Senator **Evans**. Thank you, Mr. Chairman.

Some of these first questions may be answered by Mr. Wade rather—well, whoever would like to answer them.

First, what is our current total capacity on the defense side for production of basic materials?

Ms. **Walker**. I believe Mr. Wade can answer that.

Senator **Evans**. Is it true essentially we are talking about the N-reactor and three reactors at Savannah River?

Mr. **Wade**. That is correct. N Reactor and three at Savannah River.

Senator **Evans**. How old are the reactors at Savannah River?

Mr. **Wade**. Approximately 30 years, Senator Evans.

Senator **Evans**. So, approximately the same age as the N-reactor. Maybe a little older.

Mr. **Wade**. They are all about the same age.

Senator **Evans**. Is it true that the reactors at Savannah River are now running at less than full power?

Mr. **Wade**. That is correct. The Savannah River reactors are running at 50 percent power at this time.

Senator **Evans**. Now, when the term "complacent" with the safety record was used, would you say that that probably is applicable also to the reactors at Savannah River, that people who are the operators get a little complacent because there has never been an accident at any of those reactors?

Mr. **Wade**. I do not believe complacency is the issue.

A question was raised at Savannah River about the ability of the emergency core cooling system (ECCS) to contain a worst case design basis accident. The data did not exist to satisfy—at the current day standards level to make everyone comfortable that the ECCS could handle such an accident. Pending additional review and additional calculations, the power levels of the reactors were reduced into regime that can be unquestionably handled by the emergency systems.

Senator **Evans**. It is accurate to say that DuPont, the operator, at an earlier stage did reduce by a certain amount the power at the reactors at Savannah River and then it was the National Academy of Sciences panel which recommended that further reductions in the power be made?

Mr. **Wade**. The power reductions were made in two stages. They were made initially—a reduction from 100 percent power to roughly 75, 74 percent power, and subsequently reduced to 50 percent after the—three steps. I stand corrected. DuPont did bring the reactor power down in two steps. And the third step down to 50 percent was done after the NAS concerns.

Senator **Evans**. Now, those concerns came from discoveries, as I understand, at one of the reactors, but all three were brought down because the design at those reactors is essentially the same. Is that correct?

Mr. **Wade**. That is correct.

Senator **Evans**. So, is it accurate to say that we are at a position now in terms of our whole national defense production capacity—and I think it is important for all of us to keep in mind that there is a difference between production and capacity for production, that while we may not at a certain moment need the actual production from a military reactor, we may very well need the capacity to produce from a reactor. Is that distinction an appropriate one?

Mr. **Wade**. That is an appropriate distinction and a very important one to us at the moment. Capacity is indeed a concern and a problem.

Senator **Evans**. At best how much time—with the safety changes which have been made in the N-reactor, how much lifetime is there left in the N-reactor would you say?

Mr. **Wade**. Well, again that is a function of when it is started, as you know, Senator Evans, and——

Senator **Evans**. Assuming it is restarted within months.

Mr. **Wade**. And its power level—the lifetime is of order of 1992.

Senator **Evans**. So, maybe five to six years, something of that nature.

Mr. **Wade**. That is correct.

Senator EVANS. How long would it take starting now to build and have in operation a new production reactor?

Mr. WADE. At least a decade.

Senator EVANS. At least a decade. Is it possible or certainly within the realm of possibility that a discovery would be made at some time in the next several years through continued operation of the reactors at Savannah River that would cause it to be necessary to shut down one, or if you did one, then all reactors at Savannah River?

Mr. WADE. We certainly cannot rule out that possibility. We are unaware at this time of any generic failure or potential failure that could affect all three.

Senator EVANS. I understand.

Mr. WADE. But that certainly is not a zero probability, and it is indeed a great concern.

Senator EVANS. And wouldn't it be accurate to say that that is an increasing possibility as these reactors age?

Mr. WADE. That is correct.

Senator EVANS. So, we are in a position where we cannot calculate the probabilities, but at least there is maybe a reasonable or even a significant possibility that at some time in the next 10 years, given no other decisions made, that we could be left without production capacity for military purposes.

Mr. WADE. It is certainly possible that there are events that could put us in a position where we had no production capacity at all, which would put this Nation at a risk level I believe that would be unacceptable.

We are, as you know, looking at alternatives, looking at new production reactor technologies. And very shortly we will come up with a plan that will lead us to new production capability in the out-years.

Senator EVANS. Are you supporting the request in the 1988 appropriation act for money to initiate the design and the movement toward a new or several new production reactors?

Mr. WADE. The Department has committed to building a production reactor or perhaps more than one. The Department's first opportunity to do that was in the 1989 budget, and we are in the process of considering an 1988 budget amendment. But we will move forward in 1988.

Senator EVANS. A couple more questions. Ms. Walker, how are we proceeding, or if you were required to do a comprehensive EIS on the N-reactor prior to its restart, how much time and what would it take and what would be the consequences?

Ms. WALKER. Well, first of all, I should say that the final decision on the scope of the EIS has not been made. I expect to be making that at some time in the first few weeks of August. But we are at the stage now where the scoping process has basically concluded. We are examining and analyzing the comments received. And I want to take all of those into account. I have met with representatives of the Council on Environmental Quality and, of course, we want to make the most appropriate decision.

But assuming, as I do for purposes of your question, that we were required to prepare an EIS before we resumed operations of the reactor, it may be probably anywhere from 18 months to two and a half or three years.

Senator EVANS. On page 12 of your testimony you have talked about the "formal written agreements with EPA and/or states on specific measures to correct deficiencies in complying with environmental requirements of DOE facilities. The latest of these agreements is the landmark 'Consent Order and Compliance Agreement' we signed last week with EPA for our Idaho site."

Does that potentially give an example, or would the same kind of process be appropriate in terms of the N-reactor?

Ms. WALKER. Absolutely. And further, what I would say is that we have been negotiating an agreement with EPA Region 10 for all of Hanford and environmental compliance there under RCRA and CERCLA, and hope that the Idaho agreement will serve as the format for that agreement. And it is Win Porter's hope and my own that Idaho, which is a very strong agreement for EPA, will be a model for other agreements, and that we can now more quickly resolve those. So, I would expect Hanford would be the next one that comes up, the next agreement that we are able to accomplish with EPA.

Senator EVANS. In your view would a successful agreement of that type be a substitute for an environmental impact statement?

Ms. WALKER. No. But again, we are talking about a difference between compliance with the National Environmental Policy Act which examines environmental issues related to the safety enhancement plan versus a compliance agreement with EPA for compliance in the hazardous waste area under RCRA and CERCLA. They are really different animals. I think that it is appropriate to prepare documentation under NEPA for the magnitude of the safety improvement program we have under way. And the issue now is what the scope of that will be, of course. But no, they are two different animals.

Senator EVANS. I will have other questions for the record. One final question I would like to ask here. Are you aware of any further interim reports from the National Academy of Sciences, especially interim reports that have further adverse recommendations or news about any of the reactors for that matter and the military reactors that are now in the hands of the Department of Energy and are not now being released?

Ms. WALKER. Well, as you know, outside of the letter raising the issue of the emergency core cooling system, we have not received an interim report from them.

We expect a letter report on the hydrogen mitigation plans that we asked them to review, and we expect their interim report on the production reactors in September.

Let me just ask Mr. Bunch if he has anything to contribute to that.

Mr. BUNCH. Senator Evans, we were advised yesterday that Westinghouse, the new contractor for the Hanford operations, has reached the point where they have completed their review, as requested in December, of the accelerated safety enhancement program. They have been working with us and with the old contractor, United Nuclear Corporation, throughout this process. And they have, as I understand it, come forward with a few additional recommendations for improving the strength of the operations at the N-Reactor.

I have not seen that report yet. I do not even know for sure it has been delivered to the Operations Office. When it is available, we will certainly make it publicly available.

As I said, I understand it raises no new safety questions. It does just suggest that there are some further areas in which we can strengthen the operation and improve the quality of the operation.

Senator **Evans**. Is there a draft final report or a partial draft final report in the hands of the Department at this moment?

Ms. **Walker**. No. As I understand it—and I have just been passed a note—that report is not completed by Westinghouse. It is not even completed by them yet, and we do not have a draft.

Senator **Evans**. I am not talking about Westinghouse. I am talking about the——

Ms. **Walker**. Oh, the National Academy.

Senator **Evans** [continuing]. Report of the National Academy of Sciences.

Ms. **Walker**. We have no reports from the National Academy that they have sent us. We have been promised the interim report on the production reactors. As I have indicated, I have not seen a draft. It is not available. I do not even know if they have completed it yet. And we expect a letter report on the hydrogen mitigation issue, but again, we do not have that yet either. Sometime in the next two months.

Senator **Evans**. And you have no report, either interim or final report, in hand on the Savannah River reactors by the National Academy of Sciences?

Ms. **Walker**. The National Academy has not given us an interim report yet on Savannah River. That is going to be in the September report, as I understand it. It obviously is the production reactors.

Senator **Evans**. So, there is nothing in hand at this moment.

Ms. **Walker**. Let me just ask Mr. Bunch if there is something else he wants to share on that.

Mr. **Bunch**. Senator Evans, we do not have, as Ms. Walker was indicating, a copy of the interim report. We understand that the panel is still considering the final touches on that report and they are about—and also about to complete the letter report on hydrogen mitigation.

I do understand that members of the Department have seen an early draft of one of the appendices to that report, one dealing with a very specific technical issue having to do with powder metallurgy. I have not seen that particular appendix.

To the best of my knowledge, it has been superseded by subsequent events.

Senator **Evans**. Have there been specific meetings between the NAS panel and anybody at any level in the Department of Energy regarding an oral presentation of certain aspects of the draft report?

Ms. **Walker**. Let me give one answer, and then I will give it to Mr. Bunch. He may have more specifics.

I have had two meetings with all or a portion of the members of the committee. Initially I met with them to brief them on what we were doing, what our concerns were, to discuss with them a little bit about what Secretary Herrington was hoping to accomplish at the Department. I cannot remember all of the specifics of that meeting, but as I recall, they did not give me anything. I gave them everything.

And then I met with Chairman Meserve and Steve Blush just this week to give them our thoughts on a permanent outside oversight just to let them know what we were doing, telling them whatever we did, we wanted to make sure it was something that the Academy could support as a meaningful thing. And those are the only two meetings I have had with them. And again, they have not given me the details of any of their reports.

Senator EVANS. They did not give you any clue as to what was in their report.

Ms. WALKER. No. But we have had meetings on the emergency core cooling issue because obviously we wanted to deal with that as quickly as possible.

And Mr. Bunch was in those meetings. Perhaps there is something he could contribute to this.

Mr. BUNCH. Only that Mr. Meserve, the Chairman of the National Academy of Sciences panel, has taken great care I think to assure the integrity of the panel's process. They have told us on many occasions they would not brief the Department about the contents of that report until the report had been completed and until that report had been reviewed by the National Academy peer review process which is still yet to come.

Senator EVANS. Thank you, Mr. Chairman.

Senator FORD. Mr. Chairman, I want to make a point if I can. I think we left kind of the understanding that you could leave the N-reactor open and running if it was needed for national defense. And the doctor will be here to testify later, but I think that report was unless a positive judgment is made that the requirements for defense materials warrants accepting public hazards exceeding those of commercial reactors. So, I there was, yes, you can do that.

Ms. WALKER. I agree with that.

Senator FORD. But you must accept those public hazards. And I think we kind of left that if you want it for national defense, we could go ahead with it. But there were some tradeoffs that I was trying to get to a while ago.

Ms. WALKER. Right. No, I fully agree.

Senator FORD. The tradeoffs would be then public hazards.

Ms. WALKER. I fully agree. I think, Senator Ford, we have to recognize that any of these endeavors pose risk. And the question is what level of risk do the best safety experts deem acceptable. And even given some acceptability of a risk, you still have to weigh it against the need for the facility.

And obviously you accept no risk if a facility is not absolutely needed. So, I would agree with that. And I do recall those are the more accurate words from this report.

Senator FORD. But more than commercial reactors.

Ms. WALKER. Right.

Senator EVANS. But just one more question which arises out of that, Mr. Chairman.

Wouldn't that essentially be true of all of our facilities, and the reactors at Savannah River as well as those at Hanford. None of them were designed and constructed to today's technology and today's requirements.

Ms. WALKER. Perhaps I would like Mr. Bunch to make sure that I am right here, but it is my understanding that those facilities do pose risks that are higher than certainly the newer commercial facilities. Whether there are older commercial facilities that pose similar risks, I do not know. And again, I would like Mr. Bunch to clarify since he has had NRC experience and knows more about the commercial sector than I do.

Mr. BUNCH. I think the answer to your question, Senator Evans, is simply yes. These facilities would not meet contemporary standards nor would any old plant because the standards have evolved with time.

Senator EVANS. OK. Thank you, Mr. Chairman.

The CHAIRMAN. Senator Metzenbaum.

Senator METZENBAUM. Thank you, Mr. Chairman.

Mr. Chairman, I must confess that I am tremendously interested in this subject because the Fernald plant is located 18 miles northwest of Cincinnati. I visited the Fernald plant not too long ago myself. And at that time in June of 1986, to be specific, I was assured they would take immediate action to deal with the serious health and safety problems that exist there.

I think we are all probably familiar with the fact that ABC not very long ago in a closeup piece aired in April, to be specific, publicized the allegations that the DOE and Westinghouse have not given adequate consideration to either worker safety or environmental hazards that exist at Fernald. And as a matter of fact, in one portion of that on the man who held the title of safety auditor for Westinghouse—he was fired because he would not—according to the ABC piece, because he would not come out with the appropriate kind of report.

I can only believe that responsibility of the government in this respect is so critical to the health and safety concerns of the people surrounding Fernald, and I am concerned frankly, Madam Secretary, about whether or not all that can be done or should be done is being done.

Now, out of 29 DOE facilities producing hazardous waste, the EPA has identified 13 which pose environmental concern. Two of those 13 are in Ohio. And in March, the Ohio Attorney General Celebrase filed a suit against DOE for violations of Ohio hazardous waste regulations at Fernald. And he has issued a notice of intent to file suit against the DOE for past noncompliance at DOE's enrichment facility in Portsmouth, Ohio.

The question I have of you is what are the circumstances that cause a respected attorney general who has been in office for some years to have to file suit against the DOE in order to protect their health and environment. And I am concerned as to what the reluctance is and why the people of Ohio and people of other areas as well are not getting the kind of protection that they feel they are entitled to.

Ms. WALKER. If I could, I will definitely attempt to answer that with a little introductory remark regarding Fernald.

Fernald was one of the facilities, when I first got my job as Assistant Secretary and when the Secretary first came to the Department, that was of most concern. For various reasons the condition of the plant, both from an environmental standpoint and from a safety standpoint, had been allowed to deteriorate such that we really felt something needed to be done and done quickly. And that was done. Many changes—and I do not mean just studies of problems, but I mean actual hardware changes, staff changes, contractor change. Many changes have been accomplished at Fernald. It does not mean that it is the stellar facility today that we want it to be or that it will be eventually, but there has been a change.

Fernald was number one on my list last year and expected this year in terms of the environmental and safety improvements for our budget. In other words, every year I rank the projects for the Secretary that I think should be funded in the environmental and safety area across the board for the entire Department. And Fernald has been number one. So, I think you can say it has been made a priority.

One of the things about the environmental suit that the Attorney General filed that troubles me very much is that with Secretary Herrington, we have indicated a new desire to work closely with the States and EPA. We have a Federal facilities compliance agreement with Region 5 that has jurisdiction over Fernald.

We indicated to the Ohio Attorney General that we wanted to work closely with him to make sure he had a strong agreement that would give him the assurance we would do all that he felt was appropriate to comply with environmental matters.

I personally offered to meet with him. That meeting was to be arranged with Admiral Foley and myself and the general counsel. That meeting was declined and suit was filed.

So, I have to say that while he may feel a suit was the most appropriate avenue, he did not do that thinking that the Department of Energy would not work with him. We wanted to; we still want to. And I am hopeful that that can be resolved to the satisfaction of the State of Ohio, sir, so that we can move forward to fix things that are wrong at Fernald.

Senator **METZENBAUM**. If I called a meeting, will you attend to see if we cannot make some headway on this subject with the attorney general of Ohio?

Ms. **WALKER**. Absolutely.

Senator **METZENBAUM**. I will do that.

Let me ask you some additional questions because this is a continuing concern. You indicated a willingness to help solve the problem. The residents who live near Fernald are frankly very much concerned and frightened. There are silos at Fernald referred to as K-65 storage tanks. Are you aware of those?

Ms. **WALKER**. Yes, I am, sir.

Senator **METZENBAUM**. Can you tell us what is stored in them?

Ms. **WALKER**. If you will give me just a moment.

Senator **METZENBAUM**. Sure. I think it is low-level radioactive waste.

Ms. **WALKER**. It is uranium ores. And it is my understanding also that it is the uranium decay that gives off the radon.

Senator **METZENBAUM**. I cannot hear you please.

Ms. **WALKER**. It's the uranium decay that gives off the radon gas which is the concern in the silos.

Senator METZENBAUM. Well, as I understand it, it is low-level radioactive waste that has been stored there from the atomic bomb from the Manhattan Project. It has been stored there since the 1950s.

Ms. WALKER. It has been stored there for a considerable time.

Senator METZENBAUM. And I am concerned as to what you are doing about it because we know just from the little bit we know—the scientific aspects—that after a while it starts to emit either gases or seepage into the water area. I would like to know what is being done. It seems to me it is the government's responsibility.

Ms. WALKER. It certainly is, sir. Let me just indicate briefly and then turn it over to Mr. Berube who has the more detailed facts on this.

It is my understanding that covers have been placed on the silos to correct the structural weaknesses, which were the main concern. And recommendations are now being developed for final disposition of the material in the silos and will be submitted to EPA as part of our agreement with them, the Federal facilities compliance agreement. And if Mr. Berube could confirm——

Senator METZENBAUM. Can you give me a timetable on that when the people of that area may expect some action with respect to removing that radioactive waste?

Ms. WALKER. I may have to supply that for the record, sir. I think we will have to supply that for the record. I am sorry. I just do not have the specific date proposed for that.

Senator METZENBAUM. Did you want to add?

Mr. BERUBE. Actually she covered most of what I could cover. With respect to what is in the tanks, the K-65 silos, it is uranium ore.

Senator METZENBAUM. A little louder please.

Mr. BERUBE. It is uranium ore that is in those silos, and the uranium ore also contains radium. And it is the radium that generates the radon gas.

Senator METZENBAUM. Is this waste or is this new product?

Mr. BERUBE. At the time it was placed in the silos, it was not waste. It was thought there might be a future use of that uranium ore. But that does not appear to be the case at this time. The final disposition of the material in those silos will be studied under the compliance agreement that we do have in place with EPA.

Senator METZENBAUM. As you know, last April radon gas was illegally vented from two of those storage silos. And the State of Ohio claims that Westinghouse employee Ralph Watts ordered the venting despite EPA and DOE orders to the contrary. What has DOE done to investigate and reprimand Westinghouse for that action?

Mr. BERUBE. There was an unauthorized venting of radon gas in that timeframe. I believe the Department's Inspector General has conducted an investigation of that matter. I am not familiar with the details of the investigation.

Ms. WALKER. I believe the field office also conducted an investigation, sir. And I think that it was an accidental release. The circumstances of that I think are documented in reports.

Senator METZENBAUM. The what?

Ms. **Walker**. The circumstances of that release are documented in the reports and corrective measures have been taken such that it will not reoccur.

I am sorry Mr. LaGrone is not here today. He could answer that for you. But we could supply that for the record if you wanted more detailed information.

Senator **Metzenbaum**. You are not in a position today to indicate when the removal or proper storage of this radioactive product, whether it is uranium or now radioactive waste, will occur?

Ms. **Walker**. Well, as Mr. Berube said, this is being studied under our agreement with EPA Region 5. And I do not have the end date on that, but we will supply it for the record assuming there is a date that we have.

Senator **Metzenbaum**. I guess I don't think I need to know whether it is August 1 or September 1. But are we talking about some time within 60, 90 days or sometime in the next two or three years?

Ms. **Walker**. My guess would be it would not be that soon, sir. But let me see if Mr. Berube can elaborate.

Mr. **Berube**. We will have to provide that information for the record. I apologize.

Senator **Metzenbaum**. Don't you have any guesstimate or estimate that you can give us?

Ms. **Walker**. Give us just a minute.

Senator **Metzenbaum**. Somebody must know.

The **Chairman**. Would the Senator yield while they are getting that information to ask how much radon gas was vented?

Ms. **Walker**. If you will give us a minute on that too, we may be able to find that.

[Pause.]

Ms. **Walker**. We will supply that for the record too, sir, if we might.

The **Chairman**. Was it enough to be a health hazard?

Ms. **Walker**. I do not believe so. It is my recollection it did not pose a threat to the public health, and it was a very low concentration. But again, we will supply that for the record.

[The information follows:]

Department of Energy
Washington, DC 20585

July 22, 1987

Honorable Howard M. Metzenbaum
United States Senate
Washington, DC 20510

Dear Senator Metzenbaum:

This letter responds to your specific request expressed during the July 17, 1987, hearing before the Subcommittee on Energy Research and Development for information on the Department of Energy's plans for final disposition of the K-65 silo residues at the Feed Materials Production Center (FMPC) at Fernald, Ohio. The enclosure contains the information you requested and was provided to your staff on Tuesday, July 21, 1987.

The Department is committed to protecting the public and the workers at the Fernald Site. We look forward to working with you on the continued overall improvement of conditions at the site and during future remedial actions.

As explained in the enclosed response, interim improvements as well as long-term remedial actions are being addressed pursuant to the Federal Facilities Compliance Agreement with the U. S. Environmental Protection Agency (EPA), Region V. All actions involving the K-65 silos require EPA review and approval prior to implementation. We are currently exploring the possibility of addressing the K-65 silos as a separate unit within the site-wide remedial process so that alternatives for further remediation may be considered by EPA at an earlier date.

Sincerely,

Mary L. Walker
Assistant Secretary for
Environment, Safety, and Health

Enclosure

K-65 Silos Remedial Activities

The K-65 silos have been used for storage of approximately 7,200 cubic yards of high specific activity, low-level radium bearing residues, which resulted from the uranium processing conducted at the Feed Materials Production Center (FMPC) and the Weldon Springs (Missouri) site from 1953 through 1955. Necessary maintenance improvements have been made on the silos during their use for storage purposes. In 1964, an earthen embankment was placed around the two silos to provide protective support. In 1979, all tank openings were sealed to provide total enclosure. The earthen embankment was further enlarged in 1983 to alleviate soil erosion. Protective covers consisting of prefabricated wood and metal structures were placed over the domes in 1986 following identification of cracks in the center of the domes.

Based on available information, the Department of Energy believes the K-65 silos do not present an immediate endangerment to FMPC workers or to the surrounding community. However, the Department is committed to improving the existing conditions of the silos in order to ensure that potential risks are minimized while plans for long term disposition are developed and implemented. In this regard, we are continuing to undertake interim corrective action. These actions must be approved by the U.S. Environmental Protection Agency (EPA) since the K-65 silos are included in the Federal Facilities Compliance Agreement (FFCA) between DOE and EPA, Region V, which was signed in July 1986. For those activities which require an Ohio state permit, DOE secures the necessary state review and approval.

We believe the following interim actions will provide for safe storage of these materials while long term actions are being evaluated and implemented. The short-term actions are:

-- A pressure/temperature monitoring system has been installed and is collecting data. This data will be used in developing remedial actions.

-- A radon monitoring program at the site boundary and offsite environment has been implemented.

-- A security fence and a closed-circuit TV monitoring system has been installed around the silo areas. Access to the K-65 silo area has also been restricted.

-- A plan has been developed to fill the void space between the material in the silos and the dome with a polyurethane foam. Currently, this plan is undergoing technical review prior to submission to the EPA. It is anticipated that the foam material will absorb the the radon gas and also provide structural support for the domes. If approved by EPA and Ohio EPA, the foam will be installed by the Fall of 1987. Following installation of the foam, the domes would be sealed. The installation of the sealant is temperature dependent, and the earliest practicable schedule indicates a Spring 1988 completion.

-- The DOE will analyze the material in the silos as part of the Remedial Investigation/Feasibility Study (RI/FS) conducted under the FFCA to further define its physical and chemical characteristics. Sampling will be initiated following sealing of the dome structures.

Long-term actions on K-65 silos will be evaluated under the site-wide RI/FS pursuant to Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) guidelines, which is required by the FFCA. The expected completion date for RI/FS is mid-1990. However, we are currently exploring the possibility of addressing the K-65 silos as a separate unit within the site-wide remedial process. This could enable EPA to approve remediation of the silos prior to completion of all of the studies necessary for selection of site-wide remedial actions.

At approximately 10:15 a.m. on April 25, 1986, an unauthorized radon gas release was made from the K-65 waste storage silos. The release event changed radon gas emissions already occurring through small cracks in the storage silo domes to where the radon gas was venting to the atmosphere through opened vent pipes. The release lasted for about 3 3/4 hours until approximately 2 p.m..

The total amount of radon gas released through the vent pipes during this incident was not measured. Data from the closest continuous radiation monitor located approximately 35 feet from the point of radon gas discharge were obtained for the day of the incident. However, these data on concentration are not sufficient for precise calculation of the amount of radon released during the incident.

The data available from the release incident is not sufficient to calculate specific exposures that may have been associated with the release. However, based on the best available meteorological information and radiological monitoring data collected during the release, a health hazard was not posed to the individual, an FMPC employee, closest to the release.

Senator **Metzenbaum**. You were trying to find out what the timetable was.

Mr. **Berube**. Yes. We have not been able to determine that. I apologize. We will provide the best answer we can for the record.

Senator **Metzenbaum**. Could I have it by next Monday or Tuesday—the answer to that?

Ms. **Walker**. Yes. We will provide that for you by then.

Senator **Metzenbaum**. Thank you very much.

Now, what is DOE doing about allegations that Westinghouse caused machinery to crack last January by running it at excessively high temperatures releasing a cloud of toxic and radioactive uranium hexafluoride?

Ms. **Walker**. I am sorry, sir. Could you repeat the question?

Senator **Metzenbaum**. Sure.

What is DOE doing about allegations that Westinghouse caused machinery to crack last January by running it at excessively high temperatures releasing a could of toxic and radioactive uranium hexafluoride?

Ms. **Walker**. It is my understanding, sir, that that facility was immediately shut down, has been examined, and measures taken to insure that that does not reoccur. That is basically a summary of what actions were taken.

Perhaps Mr. Wade could give you a little bit more information.

Mr. **Wade**. Senator, we are not aware—there was a problem with a vessel in the conversion facility, a new vessel in a new facility, and it appears to the best of our knowledge at this time there was a design problem. And I am personally unaware that Westinghouse—the comments you made about Westinghouse running it improperly. We believe it to be a design error.

Senator **Metzenbaum**. Will you find out and respond to me in writing the facts—or to the committee, if you please, and a copy to me?

Mr. **Wade**. Yes, indeed.

Senator **Metzenbaum**. The allegation is that Westinghouse caused the machinery to crack last January by running it at excessively high temperatures releasing a cloud of toxic and radioactive uranium hexafluoride.

Mr. **Wade**. We will provide the committee that information.

[The information follows:]

According to the DOE incident investigation, the suspected release of uranium bearing material from the Feed Materials Production Center Pilot Plant reactor vessel 2 resulted from failure of the vessel due to a complex interaction of thermal fatigue, creep rupture and surface and intergranular attack hastened by extended operation of the vessel at temperatures far in excess of those acceptable for the material of construction. Contributing factors were insufficient vessel cooling air, heat induced deformation of the counterweight yoke, improper attachment of vessel thermocouples, and the as-built mix head.

The report contained no suggestions of sabotage or deliberate improper operation to cause the incident. It appears that the predominant causes and contributing factors are extremely complex combinations of design deficiencies, poor definition of an inadequate attention to operating limits, and inadequate control of operations. All of the deficiencies will have been addressed and thorough tests will have been conducted before normal production operations are begun.

Senator **Metzenbaum**. Madam Secretary, what is the range of corrective measures that DOE can take against its defense production contractors?

Ms. **Walker**. You mean for environmental and safety matters that are not acceptable, sir?

Senator **Metzenbaum**. Yes.

Ms. **Walker**. Well, there are a range of available options. First of all, if the facility is not being properly run and poses an unacceptable risk, we can shut it down. We can penalize them through the award fee process. And in fact, that has been done at Fernald. As you know, the entire award fee was forfeited one year. And the contractor ultimately can be changed. We can remove them from the ability to run the operation, and that was also done at Fernald. So, we have that scale of measures.

And as I understand it, although Mr. Wade, because he was an Operations Manager before he was principal deputy, can speak more appropriately to this, the Operations Manager works closely with the contractor such that they express views as to management changes and that sort of thing when they think it is appropriate.

Mr. **Wade**. I think there are several mechanisms in place, Senator Metzenbaum, to assure that the facilities are operated safely and that the contractor operates in a responsible manner. Ms. Walker has described a couple of those. Certainly the actual contractual arrangement itself between the government and the contractor, having provisions which allow the contractor to earn a fee only if their conduct, and their operations are satisfactory to the Federal Government and meet the requirements of the Federal Government, is a very powerful management tool and it is used throughout our complex to assure safe operation.

Ms. **Walker**. If I might add, Senator. One of the things the Secretary has asked me to look at—as I indicated in my testimony, we are looking at additional measures to further institutionalize what the Secretary has already done. One of the things he specifically asked me to look at are enforcement mechanisms in the safety and health area for the internal oversight organization of the Department—that is, my organization—as to the facilities and contractors. So, that is one thing that is under review by my Office of Safety Policy. And you know, it may be that in the future there will be additional measures supplementary to the ones that myself and Mr. Wade have already put in place.

Senator **Metzenbaum**. I have a few more questions, and I would like to handle them rather rapidly because my time has run out.

Precisely to what extent have groundwater, soil and air contamination been reduced or eliminated at Fernald?

Ms. **Walker**. We have taken measures in that regard, and there have been improvements made. I think for the specifics I might like to direct that question to Mr. Berube.

Mr. **Berube**. If you would just give me a few moments to check some notes.

Senator **Metzenbaum**. While he is doing that, would you tell me what did you do when you heard the ABC report about the fact that the safety auditor at the Fernald plant—that his integrity had been compromised, and that the company had terminated his services because he wouldn't act in accordance with their wishes? Did you follow up on that?

Ms. **Walker**. I follow up on all those that are brought to my attention. I think the one thing I would like to say about the ABC report, sir—and we have obviously had a lot of inquiries as a result of it. Much of the problems that they raised as existing in our facilities came directly from the reviews that Secretary Herrington caused to be initiated. No credit was given to the Secretary for that at all.

In addition, a very negative picture was painted in the sense that they raised concerns. They never talked about corrective measures even though I believe they had knowledge of corrective measures.

With respect to this one individual, I would like to provide the specifics for the record. But I am very concerned that any time we have an employee that raises safety and health concerns, that they ought to be rewarded not penalized. And it is my understanding that from time to time that is not the whole story. On the ABC matter it seems to me—it has been a while now, but it seems to me we did discuss this, and I cannot recall the specifics of that individual's history or whether or not those allegations were true. I would like to provide that information to you for the record, but I am concerned and I do follow up on these.

Senator **Metzenbaum**. It was a very serious allegation. I would like to know what you did about it.

Ms. **Walker**. Okay. We will. Thank you, sir.

[The information follows:]

As a result of allegations made by Daniel J. Arthur regarding deficiencies at the Feed Materials Production Center (FMPC) and Westinghouse Materials Company of Ohio (WMCO) management response, the Oak Ridge Operations Office conducted two reviews. The first review was initiated on August 19, 1986, to assess the circumstances surrounding the decision of Mr. Arthur to terminate his employment from a position as a Methods Analyst with WMCO. The second review was initiated on September 25, 1986, to review the environmental, safety and health concerns raised by Mr. Arthur.

Both reviews were completed in October and December 1986 respectively. Recommendations were provided to the Department of Energy (DOE) FMPC Site Manager who directed WMCO to implement them. Mr. Arthur was not fired from his job, however, in the first review Oak Ridge staff report that Mr. Arthur probably resigned rather than be fired. Mr. Arthur was offered reemployment of WMCO with back pay or given back pay to the date of his resignation.

Mr. Arthur declined the offer of reemployment. Back pay was provided up to the date of his decision not to accept reemployment. Presently, all recommendations from the first review have been implemented, and 80% of the recommendations from the second review have been implemented. The remaining recommendations from the second review will be implemented by December 31, 1987.

A copy of each review is attached for inclusion in the record. Privacy Act deletions are made pursuant to 5 USC 552.

DOE F 1325.8
8-85

United States Government | Department of Energy
Oak Ridge Operations

memorandum

DATE: October 1, 1986

REPLY TO
ATTN OF: AD-44:Wilken

SUBJECT: FINDINGS AND RECOMMENDATIONS OF THE DANIEL J. ARTHUR REVIEW TEAM

TO: James A. Reafsnyder, FMPC Site Manager

On August 19, 1986, you requested the assistance of a review team from the DOE Oak Ridge Operations (ORO) Office to assess the circumstances surrounding the decision of Mr. Daniel J. Arthur to terminate his employment from a position as a Methods Analyst with the Westinghouse Materials Company of Ohio (WMCO), the operating contractor for the DOE owned Feed Materials Production Center (FMPC). The matter to be reviewed concerned the determination of the treatment afforded to Mr. Arthur during his employment at the FMPC from May 1984, until his resignation on March 24, 1986. You requested that the review team determine whether Mr. Arthur's treatment as an employee was fair, equitable, and free of harassment related to Mr. Arthur's raising of concerns which he felt potentially jeopardized worker health and safety at the FMPC. The scope of the review, however, did not include the investigation of specific health and safety issues raised by Mr. Arthur during his testimony to the House Subcommittee on Energy Conservation and Power. These issues are being addressed separately by ORO. It was understood that the review team was to develop facts and recommendations and report back to you as quickly as possible.

On September 4 and 5, 1986, the ORO review team, consisting of Dr. William R. Bibb, Director of ORO's Waste Management Division; Daniel H. Wilken, Director of ORO's Organization and Personnel Division; and John D. Rothrock, Director of ORO's Quality and Reliability Division, visited the FMPC to conduct interviews and review documentation and other pertinent information. The review team also received support from Dr. J. Peter Johnson of the Organization and Personnel Division. A return visit was made during the week of September 22, 1986, to complete the review. In addition, an interview was conducted with Mr. Arthur, in the presence of his personal counsel, Mr. Thomas E. Carpenter, on September 23, 1986. The on-site activities were concluded on September 25, 1986. This letter was prepared after our deliberations were completed and is meant to provide a final response regarding the review.

We find that Mr. Arthur had a good employment record at the FMPC. Checks of his administrative records revealed Mr. Arthur was in good standing during his employment through December 31, 1985. His 1985 performance appraisal indicates that he met expectations, was well organized in audit plan preparation and follow-through of audits, and we note that his supervisor told him that he would have liked to have given him a higher rating but felt constrained because he was in his first year of employment. A review of salary planning documents prepared at the end of calendar year 1985 indicated that Mr. Arthur was scheduled by his supervision for promotion to the next higher grade in the summer of 1986 and that at the time the salary planning document was prepared, Mr. Arthur was exceeding expectations.

We found that Mr. Arthur in January and early February 1986 received several positive commendations from WMCO management for work he had performed on T-hopper analysis and putting together an evaluation of audits done during the previous calendar year. Also WMCO management told Mr. Arthur directly that he could plan on a promotion in the June or July time frame.

In early February 1986, a series of events occurred which in our judgment were significant to Mr. Arthur's decision to resign his position. These events included personal illness, optimistic schedules for completion of assignments, and poor communication with and feedback from his supervisors. A brief chronology of the more important events follows:

- **February 4, 1986.** Mr. Arthur was informed by the WMCO physician that deleted Deleted and he was advised to contact a specialist for further tests. Mr. Arthur told his supervisor of his condition, gave him a copy of an article [Deleted], and also advised him of the need for further tests. It appears that this information was not passed on to higher level management.

- **February 7, 1986.** Mr. Arthur and his supervisor were given joint responsibility for coordinating plutonium out of specification (POOS) procedures, a new, high priority and high visibility assignment.

- **February 10, 1986.** A meeting to discuss POOS procedures was held. It was determined at this meeting that about eight procedures would be required and a goal of completing them in about two weeks (February 18) was established. There was uncertainty about the scope of the effort. Mr. Arthur expressed concern that more procedures were needed and that it would take at least two months to do a credible job. Mr. Arthur was not alone in his belief that the schedule was very optimistic.

- **February 11, 1986.** Mr. Arthur's supervisor withdrew from responsibility for coordinating the POOS procedure work. This left Mr. Arthur with the overall coordination responsibility.

- **February 12, 1986.** About this time WMCO apparently added four more procedures with no change in the target date for completion.

- **February 14, 1986.** A meeting was held to itemize all needed POOS actions. Mr. Arthur stated that the procedures (particularly the health and safety procedures) were inadequate.

- **February 16, 1986.** Mr. Arthur did not work on this holiday weekend due to previously made plans to be out of town. This absence was not received well by Mr. Arthur's supervisor, who felt significant pressure to complete the POOS work and wanted Mr. Arthur's support by working on the weekend. His supervisor made a decision to reassign Mr. Arthur's POOS work to himself and another employee. Apparently Mr. Arthur was not told that he had been relieved of POOS coordination responsibility, and he continued to work on POOS activities after his return.

- **February 18, 1986.** This was the original target date for completion of POOS procedures, but several procedures were not yet completed.

- **February 19, 1986.** A memorandum was issued postponing the target date for completion of POOS procedures to February 25.

- **February 20, 1986.** A POOS meeting was held. Mr. Arthur stated that he believed the health and safety procedure was inadequate and indicated to his supervisor that while he would assist, he did not want to assume responsibility.

- **February 21, 1986.** Mr. Arthur sought promotion and transfer to another department.

- **February 26, 1986.** Mr. Arthur talked with his supervisor about his desire to transfer to another department. As a result of this meeting, Mr. Arthur believed his supervisor would block his transfer. However, the supervisor stated to the review team that he only told Mr. Arthur that his transfer might be delayed.

- **February 27, 1986.** Mr. Arthur went to a medical specialist regarding an illness.

- **February 28, 1986.** Mr. Arthur continued on sick leave because of illness and medical tests.

- **March 3, 1986.** Mr. Arthur continued on sick leave for medical testing.

- **March 4, 1986.** Mr. Arthur reported back to work and his supervision expressed concern that he had not dedicated himself to POOS work and was off work too much. However, the review team noted that Mr. Arthur had been relieved of POOS responsibilities over two weeks before.

- **March 6 and 7, 1986.** Mr. Arthur was off work on sick leave.

- **March 10, 1986.** Mr. Arthur returned to work.

- **March 12, 1986.** A memo was issued to Mr. Arthur from the Quality Assurance Manager confirming the March 4, 1986, conversation and citing time off as being potentially career limiting. Mr. Arthur believed that the letter was a "reprimand" in preparation for an adverse action. He believed that this was due to his objections during participation in the POOS activity.

- o **March 13, 1986.** Mr. Arthur checked into University Hospital for tests.

- o **March 16, 1986.** Mr. Arthur was released from the hospital with advice from his doctor that he was experiencing stress and should take a week off from work.

- o **March 17, 1986.** Mr. Arthur wrote to the WMCO Director of Human Resources responding to the "reprimand" and requested a week off at his doctor's advice.

- o **March 24, 1986.** Mr. Arthur submitted a letter of resignation to the WMCO Director of Human Resources which outlined areas of concern in health and safety as the sole basis for his resignation. Mr. Arthur indicated to the review team that he did not cite his concern regarding the letter of "reprimand" because he had already stated that issue in his March 17, 1986, letter.

After completing extensive interviews and a review of documentation and records, we found Mr. Arthur to be highly credible. Although we found examples where Mr. Arthur did not have complete information, we had no doubt that he believed his statements to be factual and intellectually honest. It was also clear that during February 1986, both Mr. Arthur and his supervision were under a great deal of pressure to produce final POOS procedures. WMCO management created short and optimistic deadlines, to exhort intense team effort from their employees. There was a "deaf ear" to those who voiced objection to the optimistic deadlines. Although no one could predict with certainty how much work would be required to complete POOS, we note that Mr. Arthur's early assessment was fairly accurate when compared to the end result.

Mr. Arthur unquestionably was under a great deal of personal stress and pressure during February 1986, due to what he thought was the possibility of a [Deleted] He was advised of this potential condition by the doctor who was under contract to WMCO. His supervisor, although directly advised by Mr. Arthur of the possibility [Deleted] did not focus on this potential health concern. Higher management apparently was unaware of this condition. The discussion with his supervisors on March 4, 1986, and the follow-up letter on March 12, 1986, would appear to indicate that Mr. Arthur was being disciplined due to the time he had taken off to be medically tested. We believe that it was reasonable for Mr. Arthur to think that he would be "fired" and to therefore quit on March 24, 1986, rather than be terminated. While we did not find that WMCO violated any laws or regulations, we certainly believe that the management of this situation is inconsistent with ORO values, which have been communicated to all our contractors.

We did not find any evidence that would indicate that WMCO was intentionally harassing Mr. Arthur in order to get him to do something inappropriate concerning the POOS procedures. After Mr. Arthur resigned, more procedures were added and the assessment of needs continued. Our interviews indicated, however, that there was some continuing disagreement between Mr. Arthur and his supervision concerning the scope and content of his audit reports. This was particularly true under the previous contractor. In our judgment, this was not harassment, but rather professional disagreement.

In summary, our review did not disclose any violation of law, regulation, personnel procedure, or contractual requirement with respect to Mr. Arthur's treatment. However, the chronological sequence of events demonstrate, in our view, an insensitivity to Mr. Arthur's health concerns further exacerbated by the POOS assignment. No one, as far as we could determine, bothered to inquire about Mr. Arthur's medical condition. Furthermore, we believe that WMCO management was precipitous in issuing the letter that admonished Mr. Arthur for his time off and suggested potential career limitations. Mr. Arthur's time-and attendance records were reasonable in view of his situation. Finally, we are disturbed by the poor communication and feedback between Mr. Arthur and his supervision. This more than anything else might have mitigated the sequence of events leading to Mr. Arthur's decision to resign. The setting of clear job expectations, the timely review of work, and the encouragement of open and candid communications are a significant part of effective supervision; in these areas we find room for a great deal of improvement.

The following recommendations are made:

1. Mr. Arthur should be given a week to consider an offer of reemployment by WMCO. This offer should be equivalent to the salary/grade position he was scheduled to be promoted to prior to his resignation. The specifics of the offer should be cleared with your office prior to the offer.

2. Mr. Arthur should be offered back pay in consideration for his personal loss and sincere concern for the issues involved. Should Mr. Arthur reject the offer of reemployment, back pay should be rendered to the date of his rejection of reemployment.

3. Subject to his consent, Mr. Arthur's employment records should be purged of information which could be considered negative (toward Mr. Arthur) relating to events since February 1986. Any disagreements between WMCO and Mr. Arthur should be referred to your office for determination.

4. WMCO should take appropriate steps to assure that there is no harassment, retaliation, or retribution against Mr. Arthur whether he accepts the offer or not.

5. Supervisory training should be examined and deficiencies corrected. Particularly noted by the team were ineffective feedback and communication skills.

6. Timely feedback should be assured to all employees who raise environmental, health, and safety concerns.

7. A formal review should be conducted of the health and safety issues raised by Mr. Arthur to assure that corrective actions have been implemented. We note that you have already initiated this review.

Dr. William Bibb began three weeks of pre-scheduled vacation on the week that this memorandum was completed. The contents and recommendations in this memorandum were arrived at with his collaboration and consent, although he was unavailable to sign the final draft.

Should you have any questions or need any more information or assistance, please contact us at your earliest convenience.

Daniel H. Wilken

Daniel H. Wilken, Director
Organization and Personnel Division

John D Rothrock

John D. Rothrock, Director
Quality and Reliability Division

cc: Joe LaGrone
James L. Foutch
J. Peter Johnson

Department of Energy
Oak Ridge Operations
P. O. Box E
Oak Ridge, Tennessee 37831

October 2, 1986

Mr. M. B. Boswell
President
Westinghouse Materials Company
  of Ohio
P. O. Box 398704
Cincinnati, Ohio 45239

DANIEL J. ARTHUR REVIEW TEAM

Dear Mr. Boswell:

On August 19, 1986 I established a DOE Review Team to assess the circumstances surrounding Daniel J. Arthur's decision to terminate his employment from Westinghouse Materials Company of Ohio (WMCO), in March 1986. The team has completed its review and has concluded that, though WMCO did not violate any laws or regulations, the series of events and management actions which occurred beginning in early February 1986 were significant to Mr. Arthur's decision to resign his position.

I concur fully in the findings of the Review Team which are contained in the attached October 1, 1986 memorandum. WMCO is directed to take the following actions concerning Mr. Arthur as a result of this review:

1. Extend an offer of reemployment to Mr. Arthur and give him a week to consider the offer. This offer should be equivalent to the salary/grade he was scheduled to be promoted to prior to his resignation. In order to assure me that the offer is equivalent, the details of the offer are to be cleared with my office in advance.

2. Offer Mr. Arthur back pay in consideration for his personal loss and sincere concern for the issues involved. Should Mr. Arthur reject the offer of reemployment, back pay shall be rendered to the date of his rejection of reemployment.

3. Subject to his consent, purge Mr. Arthur's employment records of information which could be considered negative (toward Mr. Arthur) relating to the events since February 1986. Any

disagreements between WMCO and Mr. Arthur should be sent to my office for determination.

4. Take appropriate steps to assure that there is no harassment, retaliation, or retribution against Mr. Arthur whether he accepts reemployment or not.

The Review Team also identified other areas of concern which require your attention. The following actions are required:

1. Examine the adequacy of supervisory training and correct deficiencies. Particular emphasis should be given to feedback and communication skills.
2. Establish means to assure timely feedback is provided to all employees who raise environment, health and safety concerns.
3. Improve employee familiarity with existing systems which are available for raising environment, health and safety concerns and evaluate other means such as use of a "Hot Line" for employees to raise issues to management attention.
4. Improve the management system for control of overtime.

You are requested to promptly implement the above actions. A report of the specific actions to be implemented by WMCO and the schedule for completion should be provided to my office no later than October 17, 1986.

A DOE Task Team to review specific health and safety issues raised by Mr. Arthur, during his testimony to the House Subcommittee on Energy Conservation and Power, has been established. The team is reviewing available documentation and will be on site to conduct the review the week of October 6.

Sincerely,

James A. Reafsnyder

James A. Reafsnyder
Site Manager

DP-84:Reafsnyder

Enclosure:
As stated above

cc: Joe La Grone, M-1, ORO
Jim Foutch, DP-80, ORO
Daniel Wilken, AD-44, ORO
William R. Bibb, ER-12, ORO
John D. Rothrock, SE-34, ORO

U.S. DEPARTMENT OF ENERGY
P.O. BOX "E"
OAK RIDGE, TN 37831

DOENEWS:

October 2, 1986

NOTE TO EDITORS AND NEWS DIRECTORS:

James A. Reafsnyder, Manager of the Department of Energy's Site Office at the Feed Materials Production Center, in testimony before the House Subcommittee on Energy Conservation and Power, Committee on Energy and Commerce, stated that he would conduct a review of the circumstances involved with the resignation of Daniel J. Arthur, a Methods Analyst with Westinghouse Materials Company of Ohio, the contractor for FMPC. The review was conducted by a team from the Department's Oak Ridge Operations at Mr. Reafsnyder's request. A copy of the team's review and Mr. Reafsnyder's letter to Westinghouse is attached for your information.

Department of Energy
Oak Ridge Operations
P. O. Box E
Oak Ridge, Tennessee 37831

December 3, 1986

Mr. M. B. Boswell
President
Westinghouse Materials Company
of Ohio
P. O. Box 398704
Cincinnati, Ohio 45239

Dear Mr. Boswell:

TASK TEAM TO REVIEW CONCERNS RAISED BY DANIEL J. ARTHUR

On September 25, 1986, I established a DOE Task Team to review concerns raised by Daniel J. Arthur in his affadavit to the Government Accountability Project and in his August 13, 1986 testimony before the House Subcommittee on Energy Conservation and Power. Specifically, I asked that the review concentrate on environmental, safety and health concerns raised by Mr. Arthur and determine if those concerns have been resolved or if satisfactory plans are in place for resolution. The team has completed its review and reported on the 19 concerns raised by Mr. Arthur.

I concur in the findings of the Task Team which are contained in the attached November 24, 1986 memorandum transmitting the Task Team's report. WMCO is directed to implement the recommendations presented in the attached report and summarized below. Some of the recommendations are similar to findings of other DOE audits and appraisals including the DOE Technical Safety Appraisal performed in April 1986.

WMCO should:

1. Enhance efforts to enforce all environmental, safety and health rules at the FMPC including smoking in contaminated areas of the production plants.

2. Establish procedures for discarding used respirators.

3. Accelerate efforts to provide adequate radiation area and contamination control postings in the production plants.

4. Establish a program to identify all operations and maintenance activities requiring respirator protection and update SOP's to include specific instructions on respirator requirements. Also, a routine audit program should be

established to assure that workers comply with respiratory protection requirements. Violations of requirements should be documented and reported to management for prompt action.

5. As T-Hopper custodian, WMCO should initiate a leak testing program for T-Hoppers used to ship UF_4 from Paducah to the FMPC. The DOE Site Office has requested that Paducah and Hanford personnel enchance their participation with WMCO in preparation of the T-Hopper guidance document.

6. All critical environmental, safety and health systems should be identified and included in the Preventative Maintenance System. Items identified in the task team review include scales, hoists, and cranes.

7. Mr. Arthur's rewrite of SOP-5-C-104 should be reviewed and appropriate additions are to be incorporated in the current (8-15-86) version of the SOP.

8. Develop procedures for laundry operations.

9. Check to assure all cranes, hoists, slings and other lifting devices are labeled with capacity signs and certified to capacity.

You are requested to promptly implement the above recommendations. A plan for the specific actions to be implemented should be provided to my office by December 23, 1986.

Sincerely,

James A. Reafsnyder

James A. Reafsnyder
Site Manager

cc w/encl:

William R. Bibb, DP-80, ORO
Daniel H. Wilken, AD-44, ORO
Richard L. Egli, SE-30, ORO
Ralph E. Erickson, DP-133.1, GTN

cc w/o encl:

Steven G. Casto, AD-45, PED
Jake K. Alexander, SE-33, ORO
Andy C. Bassett, SE-332, ORO
Patrick L. Slattery, SE-34, ORO

[illegible]

United States Government **Department of Energy**

Oak Ridge Operations

memorandum

DATE: November 24, 1986

REPLY TO
ATTN OF: AD-44: Casto

SUBJECT: **REVIEW OF DANIEL ARTHUR'S CONCERNS RELATING TO ENVIRONMENTAL, SAFETY AND HEALTH ISSUES AT DOE'S FMPC. FERNALD OHIO, DATED NOVEMBER 24, 1986**

TO: James A. Reafsnyder, DOE's FMPC Site Manager

On September 25, 1986, you requested the assistance of a review team from DOE Oak Ridge Operations (ORO) office to assess the environmental, safety and health concerns raised by Daniel Arthur in his August 13, 1986 testimony before the House Subcommittee on Energy, Conservation and Power. The Team has completed its review. Our review findings and conclusions are based on examinations of various documents, interviews with DOE and WMCO personnel, and observations made during validation tours at the plant site. Enclosed you will find copies of the report for your review and retention.

Should you have any questions, or require additional information, please contact me at your earliest convenience.

Steven G. Casto

Steven G. Casto
Chairman, Management Analyst
O&P Division

Attachment

SGC:lmd

REVIEW OF DANIEL ARTHUR'S CONCERNS RELATING TO ENVIRONMENTAL, SAFETY AND HEALTH ISSUES AT DOE'S FEED MATERIALS PRODUCTION CENTER FERNALD, OHIO

DATE: NOVEMBER 24, 1986

U. S. DEPARTMENT OF ENERGY
POST OFFICE BOX E
OAK RIDGE, TENNESSEE 37831

INDEX

ISSUE NO.	ISSUES	PAGE
1	LABORATORY BUILDING CONTAMINATION LEVELS	3
2	CONTAMINATION LEVELS IN OPERATION BUILDINGS	5
3	USE OF RESPIRATORS IN OPERATIONS BUILDINGS	7
4	IMPROPER OPERATION OF THE SOLID WASTE INCINERATOR	8
5	IMPROPER OPERATION OF LABORATORY BUILDING DUST COLLECTOR	9
6	NO PROCEDURES FOR DUST COLLECTORS IN PRODUCTION PLANTS	11
7	T-HOPPER CONTAMINATION	12
8	ES&H IMPLICATIONS OF ALLEGED PROHIBITION OF AUDITS OF PLANT SCALES; ADEQUACY OF PROCEDURE FOR PLANT 5 SCALES	19
9	ADEQUACY OF PROCEDURES, FAILURE TO FOLLOW PROCEDURES FOR "DERBY BREAKOUTS"	20
10	ADEQUACY OF PERSONNEL RADIATION MONITORING PROCEDURES AND EQUIPMENT	22
11	RISK OF CRITICALITY ACCIDENT AS A RESULT OF NOT FOLLOWING MANUFACTURING SPECIFICATIONS (MS'S)	23
12	PROBLEMS WITH PROCEDURES FOR PROCESSING "PLUTONIUM OUT OF SPECIFICATION (POOS)" MATERIAL	24
	12A IMPROPER PROCESSING OF PLUTONIUM CONTAMINATED ASH RECEIVED IN 1980, AND PROCESSED IN 1982	24
	12B ADEQUACY OF HEALTH AND SAFETY PROTECTION MEASURES FOR 1986 POOS MATERIALS CAMPAIGNS	28
13	NON COMPLIANCE WITH WATER TREATMENT REQUIREMENTS	31
	13A WATER PLANT SOP DEFICIENCIES	31
	13B ADEQUACY OF "ROUTINE" OR "DAILY" INSPECTIONS; WATER PLANT OPERATIONS	32
	13C FROZEN WATER SAMPLES	33
	13D ADEQUACY OF OPERATIONAL PROCEDURES FOR CHEMICAL PITS	34
	13E ADEQUACY OF PROCEDURES FOR CERTAIN WASTEWATER TREATMENT FACILITIES	35
	13F CROSS CONTAMINATION OF WATER SAMPLES	36

ISSUE NO.	ISSUES	PAGE
	13G ADEQUACY OF H_2SO_4 STORAGE AT CLEARWELL	37
	13H ADEQUACY OF WATER PLANT LABORATORY PROCEDURES	38
	13I ADEQUACY OF RECORDS FOR CHEMICAL SHELF LIFE	39
	13J ADEQUACY OF TDS SAMPLING PROCEDURE FOR SEWAGE SAMPLES	40
14	DISCONTINUATION OF URANIUM AND OTHER MONITORING AT SHALLOW TEST WELL NO. 1	41
15	EXPOSURE LIMITS IN THORIUM STORAGE AREAS	43
16	LAUNDRY PROCEDURES FOR CONTAMINATED CLOTHING	45
17	ALARM SYSTEMS COMPLIANCE WITH OSHA 1910.165, NFC 72F, AND ANSI 2.4	46
18	GAS ODOR IN LABORATORY BUILDING BASEMENT	48
19	ADEQUACY OF PROCEDURES FOR HOISTS AND CRANES	49

ACRONYM LISTING

WMCO - Westinghouse Materials Company of Ohio
NLO - National Lead of Ohio
ALARA - As Low As Reasonably Achievable
FMPC - Feed Material Production Center
ES&H - Environment Safety and Health
DOE - Department of Energy
SWOAPCA - Southwestern Ohio Air Pollution Control Agency
EPA - Environmental Protection Agency
HEPA - High Efficiency Particulate Air
SOP - Standard Operating Procedure
MC&A - Materials Control and Accountability
QC - Quality Control
PM - Preventive Maintenance
QCA - Quality Control Audit
QA - Quality Assurance
MS - Manufacturing Specifications
NCS - Nuclear Criticality Safety
TDS - Total Dissolved Solids
H&SD - Health and Safety Division
RWP - Radiation Work Permit
NESHAPS - National Emission Standards for Hazardous Air Pollutants

REVIEW OF DANIEL ARTHUR'S CONCERNS RELATING TO ENVIRONMENTAL, SAFETY AND HEALTH ISSUES AT DOE'S FEED MATERIALS PRODUCTION CENTER FERNALD, OHIO

TEAM ASSIGNMENT

In his testimony before the House Subcommittee on Energy Conservation and Power on August 13, 1986, Mr. Daniel J. Arthur, an employee with NLO/WMCO between May, 1984 and March, 1986, raised a number of concerns regarding the adequacy of certain elements of the environment, safety and health programs at the FMPC. The task team was commissioned at the request of James A. Reafsnyder, FMPC Site Manager, to conduct an assessment of the specific ES&H issues identified by Mr. Arthur in his testimony transcript, his accompanying affidavit, and his March 24, 1986 letter of resignation. Specifically, the team was given the following assignments:

1. Review the three documents and identify all auditable ES&H issues raised by Mr. Arthur;

2. For issues requiring corrective actions, determine if the appropriate actions have been taken, are being taken, or are definitively planned;

3. Verify that appropriate remedial actions are being executed via on site inspection and/or audit discussion with site personnel;

4. Submit recommendations for any additional action believed necessary to resolve valid ES&H issues.

The team reviewed the documents and identified ES&H issues raised by Mr. Arthur. Those issues, the teams findings relative to each and, in some cases, recommendations for further actions are presented in this report.

As team members of the Review of Daniel Arthur's Concerns relating to Environmental, Safety and Health Issues, at DOE's Feed Material Production Center in Fernald, Ohio, the undersigned concur with the findings, conclusions, and recommendations of this report.

Steven G. Casto; Chairman
Management Analyst,
ORO Organization and Personnel Division
Steven G. Casto

James K. Alexander; Member
Environmental Engineer,
ORO Environmental Protection Division
James K Alexander

Andrew C. Bassett; Member
Health Physicist,
ORO Safety and Health Division
Andrew C. Bassett

Patrick L. Slattery; Member
Quality Assurance Engineer,
ORO Quality and Reliability Division
Patrick L Slattery

ISSUE NO. 1: LABORATORY BUILDING CONTAMINATION LEVELS

o TESTIMONY TRANSCRIPT; PAGES 2 AND 3

> "The building in which I worked, the Laboratory Building, was contaminated with uranium dust from personnel tracking it into and throughout the building. Contaminated shoes and clothing were strung throughout the corridors and even placed on benches that were used for coffee breaks. A layer of radioactive dust also covered the cabinets, shelves, and horizontal surfaces throughout the building."

o AFFIDAVIT; PAGE 3

> "My first impression was that the facility was antiquated and in poor condition. I immediately noticed that the building where I worked, the Laboratory Building, was contaminated with uranium dust from personnel wearing process shoes and clothing into and throughout the building. Process shoes and clothing were strung throughout the corridors (particularly the west corridor) and even placed on benches that were used for coffee breaks. A layer of dust also covered the cabinets, shelves, and horizontal surfaces throughout the building."

FINDINGS

Contamination surveys conducted in September and October, 1986 indicate low levels of removable contamination throughout the Laboratory Building. During Mr. Arthur's period of employment, the west hall of the Laboratory Building was a designated change area and there was no control over building ingress from contaminated production areas. The fact that a vending machine and a refrigerator were, until recently, located in the west hall change area indicates that areas cluttered with contaminated process shoes and clothing were also used for "coffee" breaks. Two investigation team members toured the Laboratory Building on October 9, 1986. Horizontal surfaces were not excessively dusty at this time; however, the investigators can draw no conclusions regarding the cleanliness of the building prior to Mr. Arthur's March 1986 resignation. Current conditions may reflect the recent cleanliness campaign in the Laboratory Building.

WMCO has taken steps to improve contamination control practices in the Laboratory Building. These steps include:

1. Zoning of the building into "potentially contaminated" and "radiologically clean" zones with established contamination control points for employee self-monitors and personnel contamination friskers.

2. The removal of food service machines and refrigerators from potentially contaminated areas.

3. Contamination control training for laboratory workers.

4. Restrictions on the movement of radioactive materials.

5. Improved source control practices.
6. The requirement for shoe covers and labcoats in certain labs.
7. Increased cleaning efforts throughout the building.
8. Discontinued use of the laboratory's west hall change area.
9. Building ingress controls for production workers in contaminated clothing.

CONCLUSIONS

The concerns pertaining to Laboratory Building contamination control have been verified through documentation reviews and conversations with the health physics staff.

Recent efforts undertaken by WMCO to improve contamination control within the Laboratory Building, when completely implemented, will help to assure that contamination levels and worker exposure potential are maintained ALARA.

ISSUE NO. 2: CONTAMINATION LEVELS IN OPERATION BUILDINGS

o TESTIMONY TRANSCRIPT; PAGE 3

> "In the operation buildings, I found layers of uranium dust; magnesium fluoride, green salt, orange oxide and uranium saw chips covered the floors to a level of one-quarter inch thick. At times, the air was so full of uranium dust I had trouble breathing, and afterwards, I got a sore throat."

o AFFIDAVIT; PAGE 4

> "In the operation building, I found layers of uranium dust; magnesium fluoride, green salt, orange oxide and uranium saw chips covered the floors to a level of one-quarter inch thick. At times, the air was so full of uranium dust I had trouble breathing, and afterwards, acquired a sore throat. This was especially true in Production Plants 1, 4, 5, and 9."

FINDINGS

Evidence of magnesium fluoride, green salt (UF_4), and orange oxide (UO_3) were noted by investigation team members in only a few areas of the production plants. Uranium metal shavings and saw chips on the floors around cutting and machining equipment were also noted. Spills in most areas of Production Plants 1, 4, 5 and 9 were not evident. At the time of the investigation team tour, the UF_4 T-hopper dumping station in Plant 4 was the only area with appreciable visible floor contamination. Respiratory protection is a mandatory requirement in this area. In discussions held with production workers, it was stated that spills are generally cleaned up on the shift that they occur. One worker stated that contamination control practices have improved since Westinghouse took over the FMPC contract; however, most workers agreed that the current contamination status in the production plants (as evidenced by visual inspection) is not appreciably different than it was during Mr. Arthur's period of employment. Workers were in general agreement that Mr. Arthur overstated the extent of uranium contamination in the operation buildings.

Recent contamination surveys conducted in the production plants do not, on average, reveal excessive removable contamination levels for a uranium processing plant. In June 1986, WMCO established a removable contamination limit of 10,000 $d/m/100cm^2$ for production work areas. Cleaning must now be performed if removable contamination levels exceed this limit, and respirators must be worn until the area is cleaned. Vacuuming and mopping of process area floors are routinely performed to maintain contamination levels at a fraction of this limit in general work areas.

Of 21 production workers interviewed, none have had trouble breathing or acquired sore throats as a result of their work assignments. These individuals work daily in the production plants identified in Mr. Arthur's testimony.

Although health physics and contamination control practices at the FMPC are improving, several problems identified during the investigation team tour of the production plants require the immediate attention of WMCO management:

1. Cigarette butts were observed in the most highly contaminated plant areas. One butt was ground out on a barrel rimmed in a deposit of green salt at the UF_4 T-hopper dumping station in Plant 4. Smoking is prohibited in all process areas. This rule should be enforced.

2. Many respirators were found to have been discarded on contaminated surfaces. One was found laying on a rag covered with green salt. The practice of discarding respirators in this way should be addressed immediately. This appears to be a common problem throughout the production plants. Assurances should be given that personnel do not don contaminated respiratory equipment.

3. The current level of contamination control and radiation area postings in the production plants is inadequate. The health physics staff acknowledges the need for additional posting and is currently working on this problem. These efforts should be accelerated. A uniform approach to contamination control zone posting should be adopted throughout the plant.

CONCLUSIONS

Spills do occur in some areas due to the nature of the operations performed in those areas; however, these areas are limited and spills are routinely cleaned.

None of the production workers interviewed by the investigation team have experienced breathing problems or sore throats as a result of their work assignments.

RECOMMENDATIONS

1. WMCO should enforce the rule that prohibits smoking in contaminated areas of the production plants.

2. WMCO should establish procedures for discarding used respirators.

3. WMCO should accelerate efforts to provide adequate radiation area and contamination control postings in the production plants.

ISSUE NO. 3: USE OF RESPIRATORS IN OPERATIONS BUILDINGS

o TESTIMONY TRANSCRIPT; PAGE 3

"Respirators and masks were not being worn by personnel."

o AFFIDAVIT; PAGE 4

"Respirators and masks were not being worn by personnel."

FINDINGS

Respirators have historically been required for entry to process enclosures. They have also been required on jobs involving "dusty conditions" and in areas with airborne uranium concentrations exceeding 100 alpha d/m/m^3. Enforcement of mandatory respirator requirements has not been satisfactory, and several instances of noncompliance with respiratory protection rules have been noted by the DOE as recently as two months ago.

The instructions given in Standard Operating Procedures to don respirators when "dusty conditions" exist is open to interpretation in the workplace. In-vivo lung counting data from May, 1986 indicate significant uranium lung burdens among many chemical operators. Lung doses are maintained below the DOE Annual Radiation Protection Standard of 15,000 mrem/year; however, the investigation team is confident that lung dose reductions can be achieved through a better definition of areas requiring mandatory respiratory protection (with explicit requirements for respirator usage) and stricter enforcement of respiratory protection requirements.

The WMCO health physics staff is currently evaluating airborne uranium concentrations in the production plants. Thus far, six Production Plant areas have been identified as respirator zones. WMCO now requires respiratory protection if "normal" (i.e., average) airborne uranium concentrations exceed 25% of the occupational U-238 Concentration Guide. In keeping with the ALARA philosophy, respirators should also be required on all jobs with potential for creating "dusty conditions." Operators should not wait until "dusty conditions" develop before donning respirators.

CONCLUSION

Respirators were used for certain operations during Mr. Arthur's period of employment at the FMPC. Production workers have verified this fact. The statement that respirators were not worn by personnel cannot be substantiated as a general observation; however, there is no reason to doubt that Mr. Arthur could have observed violations of respirator requirements in the production plants. WMCO is currently taking steps to rectify respiratory protection deficiencies at the FMPC.

RECOMMENDATION

WMCO should establish a routine audit program to assure that workers comply with current and future respiratory protection requirements. Violations of mandatory requirements should be documented and reported to management.

ISSUE NO. 4: IMPROPER OPERATION OF THE SOLID WASTE INCINERATOR

o TESTIMONY TRANSCRIPT, PAGES 4 AND 5

> "In an audit of the solid waste incinerator at Fernald in the summer of 1985, I discovered that materials contaminated with radioactive materials were being burned. Fernald does not have a license for that. Radiation could conceivably go up the stacks and into the atmosphere."

FINDINGS

Mr. Arthur's April 3, 1985 Quality Control Audit Report No. 4.08 contained one item directly concerned with radiological control of incoming solid waste:

"Discarded skids that can be burned in the incinerator are marked with a white stripe. The white stripe indicates that the skids are free from radioactive contamination and have been checked by the Health and Safety Department. Currently, there is no information in the SOP about the marking on the skids."

In the audit follow-up and completion reply dated November 20, 1985, operations management indicated the incinerator SOP would be amended to include procedures for marking burnable and nonburnable skids.

A review of documentation concerning the April 28, 1986 decision to suspend operations at the solid waste incinerator indicates this was an internal WMCO/DOE decision following an environmental audit that revealed inadequate control of radioactivity levels in the waste being burned relative to the recently promulgated NESHAPS regulations. Ohio EPA and the Southwestern Ohio Air Pollution Control Agency (SWOAPCA) were informally notified of the suspension of the incinerator operations shortly after the decision was made. In a meeting on May 7, 1986, Ohio EPA personnel formally requested that the operation of the incinerator be suspended. In a letter dated May 12, 1986, SWOAPCA also formally requested the incinerator remain out of operation until written permission from SWOAPCA could be granted.

CONCLUSION

A problem associated with the proper control level for radiological contamination of burnable solid waste was identified at FMPC in early 1986. A WMCO environmental compliance audit performed in April, 1986 resulted in shutdown of the incinerator.

The solid waste incinerator remains out of service pending further permitting actions and the installation of air emission control improvements.

ISSUE NO. 5: IMPROPER OPERATION OF LABORATORY BUILDING DUST COLLECTOR

o TESTIMONY TRANSCRIPT, PAGES 5 AND 6

> "The uranium dust in the Laboratory Building was unusually thick, and I asked why such conditions were tolerated. I was informed that there was only one dust collector and that it was in the basement. A dust collector is supposed to clean the air in the building, and filter out the excess radioactive dust. I went to the basement and took a look at the dust collector, and then asked who was responsible for changing the bag on this particular collector. Nobody knew. So I asked where the procedures were for changing the collector's filter bag. I discovered that there were no procedures. The bag, as far as I could determine, had never, in the life of the plant, been replaced. Months went by, and finally, in June, 1985, I insisted that the bag be replaced, which it was. Mr. Graver, Mr. Fallings and I witnessed the removal of the old bag which literally fell apart as it was removed. Uranium dust had not only been building up in the Lab Building for years, but dust was bypassing the bag and going straight up the stack."

o AFFIDAVIT, PAGE 8

> "The uranium dust in the Laboratory Building was unusually thick, and I inquired about why such conditions were tolerated in February, 1985. I was informed by Mr. Tippenhauer that there was only one dust collector and it was in the basement. I went to the basement and took a look at the dust collector, and then asked who was responsible for changing the bag on this particular collector. Nobody knew. So I asked were the procedures were for changing the collector's bag. I discovered that there were no procedures. The bag, as far as I could determine, had never, in the life of the plant, been replaced. Months went by, and finally, in June, 1985, I insisted that the bag be replaced, which it was. Mr. Graver, Mr. Fallings and I witnessed the removal of the old bag which had disintegrated. Uranium dust had not only been building up in the Lab Building for years, but dust was bypassing the bag and going straight up the stack."

FINDINGS

The G-15-001 Spencer Dust Collector is part of the hand-held vacuum outlet system that services rooms W-44, W-34, C-41, C-25, W-28, S-39, N-19, N-37 and W-22 in the Laboratory Building. The Spencer unit does not filter recirculated air from some or all parts of the Laboratory Building.

Until recently, there were no formal procedures for the operation or maintenance of this equipment. However, a review of the files maintained by the Analytical Department yielded a memo written on December 13, 1984 that documented the fact that the superintendent of the Laboratory Building had assumed responsibility for operating the system many years earlier.

A five gallon can which received the filtered dust from the unit was removed and emptied on a routine basis. Dust is removed from the bags at least once a week with a hand operated shaker. A check with WMCO general maintenance personnel indicated that, prior to January of 1986, when the Spencer Unit was added to a new, formal Preventive maintenance program, no permanent records of maintenance or repairs performed on an "as requested" basis would necessarily have been kept. Prior to mid-1985, it probably had been many years since the filter bags were visually inspected.

Several of the WMCO employees who were involved in the removal of the old bags from the unit during the summer of 1985 recall that a number of the individual bags had become detached from the overhead hanger, were heavily weighted with accumulated dust and had fallen down into the dust hopper. The Spencer Unit contains a parallel array of 19 separate bag filters. A review of NLO/WMCO files indicates replacement bags were ordered on July 7, 1985. Records further indicate the first set of new bags provided by Spencer had been received, installed and tested by September 24, 1985. These Spencer cotton twill bags were determined to be unsatisfactory based on the results of an orange dust permeability test. Tighter weave bags were ordered from another manufacturer and had been installed, tested and approved by November 4, 1985.

CONCLUSION

After the discovery of the problems associated with the Plant 9 air emission control systems in December, 1984, all exhaust air cleaning systems at the FMPC were subjected to careful operational inspections and reviews. Documentation indicates that the building superintendent initiated efforts to identify and clearly assign specific maintenance and operational responsibilities for the Spencer Vacuum Unit in late 1984. A failure of the vacuum system's filters would not result in a dust buildup problem in the areas serviced by the system.

At this time, the system is being substantially improved. A Ludlum stack monitor and a HEPA filter are being installed downstream of the Spencer Unit. There are plans to replace the filter bag array with disposable cartridges. A formal request for a formal Standard Operating Procedure (SOP) for the Spencer Unit was submitted in September, 1985. A draft SOP has been prepared and is being circulated within WMCO for approval.

ISSUE NO. 6: NO PROCEDURES FOR DUST COLLECTORS IN PRODUCTION PLANTS

- TESTIMONY TRANSCRIPT; PAGE 6

> "I discovered that many of the dust collectors in the production plants lacked procedures, notably the portable dust collectors."

- AFFIDAVIT; PAGE 8

> "I discovered that many of the dust collectors in the production plants lacked procedures, notably the portable dust collectors."

- RESIGNATION LETTER; PAGE 2

> "Even with all the attention given to dust collecting equipment, for the past 20 months, procedures still do not exist for all dust collecting equipment at the Fernald Site."

FINDINGS

Discussions with WMCO personnel indicate there have been procedures for all plant production area dust collectors for many years. However, following the discovery of the operational problems with the Plant 9 air emission control systems in late 1984, procedures were subjected to an intensive reevaluation and extensive revisions were undertaken for many of the procedures. Most of the procedures had been rewritten, approved and were in use at the time of Mr. Arthur's resignation. At this time, revised procedures for the Refinery's air emission control equipment have not been finalized and approved. However, only limited operations have been carried out at the Refinery for the last eighteen months.

Although no formal procedures were used for many years for the portable dust collectors because of the relatively uncomplicated functions of this equipment, procedures were being developed in early 1986. These procedures are now in use and formal SOP documents are being circulated within WMCO for official approval.

CONCLUSION

There were efforts underway to extensively enhance inadequate procedures for dust collector systems after December, 1984. The portable equipment did not have formal procedures for many years. However, draft procedures had been developed and were in use by early 1986. Formal adoption of these procedures is expected relatively soon.

ISSUE NO. 7: T-HOPPER CONTAMINATION

o TESTIMONY TRANSCRIPT, PAGE 8

> "My investigation, performed seven months after the July T-Hopper incident, revealed fourteen areas that were deficient. On February 18, the Hanford facility again received another contaminated T-Hopper from Fernald."

o AFFIDAVIT; PAGE 22

> "Despite the obvious and glaring inadequacies*, T-Hopper shipments continued throughout this period."

* As defined by DOE Report:

o AFFIDAVIT; PAGES 23 AND 24

"...investigation revealed fourteen areas that were deficient, including:

- No program had yet been established by the Materials Control and Accountability Department for periodic weight verification of T-hoppers.
- No tamper-proof seals on bottom closure of T-hopper.
- No leak testing maintenance procedures and bottom gasket replacement.
- Leak testing is not performed on T-hoppers from Paducah by FMPC - instead it is performed by Paducah.
- An Environment, Safety & Health procedure had not yet been written on radiation checking and visual inspection for all incoming T-hoppers.
- There were discrepancies in washer sizes.
- No operating procedure for 5-year leak testing and bottom gasket replacement, despite commitment to contrary.
- ES&H procedure which includes information on the maximum radiation level acceptable was still in the process of being written.
- Many areas requiring development of SOP and audit procedures, including:
    - Need for revision in procedure to include information on scale preparation and use by production personnel.

- Need for maintenance standards for:
    - * scale calibration revision
    - * calibrating NLO-fabricated checkweight (revision needed).

o AFFIDAVIT; PAGE 25

"...the three items that the Appraisal Team found lacking were enough to ban Fernald from shipping T-hoppers, two days later, February 14, 1986. However, this was not in time to prevent yet another contaminated T-hopper shipment from Fernald to Hanford on February 18, 1986."

o AFFIDAVIT; PAGES 24 AND 25

"On February 11, 1986, a DOE Transportation Safety Appraisal team visited the site and spent the whole day reviewing Fernald's procedures. Four DOE personnel, including Mr. Pryor, Mr. Hansen, Mr. Fouck and Mr. Slatterly conducted the review. On February 12, 1986, they held a close-out meeting to discuss their findings. I was told to attend the meeting by Mr. Weichold. On the way to the meeting, I was told by Mr. Weichold that, "If you are asked any questions, be careful what you say. Say as little as possible." I knew what he was referring to, because I realized that the true state of affairs in the Transportation Department in relation to T-Hoppers was such that Fernald was in jeopardy of being suspended from being able to transport the T-Hoppers at all. Conceivably, production could grind to a halt if that happened.

The meeting occurred, and sure enough, nothing at all was mentioned about my investigation. At the meeting was Mr. Grumski, Mr. Weichold, Mr. Block of the Transportation Department, myself and the DOE representatives. Incredibly, the DOE team only uncovered three items that they felt were of concern. Two of those items were problems I identified in my investigation. DOE, with a four man investigation team, had totally overlooked twelve major problems that one single auditor had found in twenty hours. It was clear that Westinghouse management was not about to volunteer this information. It was also clear that DOE had failed to uncover my investigation report. Presumably, all they would have to do was to ask for all Westinghouse reviews in order to receive my investigation report.

Westinghouse's failure to bring up my investigation, and management's "advice" to me to not bring it up unless asked, was worrisome."

o AFFIDAVIT; PAGE 26

"Two days later, Mr. Britton wrote to the DOE, announcing that Fernald management had completed correcting the three items that the DOE team had found wanting. Again, no mention was made of my investigation report. Mr. Britton had failed to raise the following information to DOE that my investigation had revealed:

(1) No procedure existed that included information on the weighing, receiving and shipping inspection requirements for T-Hoppers from Paducah;

(2) No environmental, safety and health procedure existed that included information on how to perform a radiation check and visual examination on incoming T-Hoppers;

(3) No ES&H procedure existed that included information on how to perform a smear test and radiation check on T-Hoppers;

(4) No procedure existed that included information on how to replace the bottom gasket of the T-Hoppers;

(5) No procedure existed that included information on specifications for bottom gasket of the T-Hoppers;

(6) No procedure existed that included information on how to tack weld the two opposite bolts at bottom closure of T-Hopper;

(7) A program had not been established for periodic weight verification of T-Hoppers and T-Hopper dollies;

(8) A program had not been established for five-year interval leak testing and bottom gasket replacement on T-Hoppers;

(9) The following procedures did not include information on Scale No. 4-44, which is used to weigh T-Hoppers;

o AFFIDAVIT; PAGE 27

> "Westinghouse affirmatively misled the DOE by failing to bring to their attention information from their audit files of relevance to the DOE's investigation. Production concerns obviously played a heavy role in Westinghouse management's failure to do so. Finally, Westinghouse failed to respond and follow-up on my investigation report.
>
> For DOE's part, DOE overlooked many important problems identified by my audit. A team of four investigators failed to identify 12 major items uncovered by my investigation in the same amount of time. To its discredit, DOE even failed to unearth my investigation report."

o AFFIDAVIT; PAGE 38

> "Westinghouse claimed that the T-Hopper was sent out on January 30, 1986*. This is of small reassurance, since Westinghouse had sent a letter to DOE on January 28 guaranteeing that radiation surveys were being conducted. In fact, the surveys were performed, but without benefit of a written procedure. Westinghouse attempted to escape blame by claiming that they implemented the corrective actions promised to DOE. Westinghouse had performed a radiation survey on the T-Hopper - three weeks prior to shipment. They had followed a flawed and vague procedure, exactly the danger that I tried to point out in my investigation report."
>
> * Shipment received in Hanford on February 18, 1986.

o RESIGNATION LETTER; PAGE 2

> "Fernald Site continues to violate DOE Order 5480.3, "Safety Requirements for Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes," and Code of Federal Regulations, Title 49, Part 173, Subpart 1 that includes DOE regulations for shipping radioactive materials. Shipments of contaminated T-hoppers from Fernald Site were received in Hanford, Washington, in July, 1985, and again in February, 1986."

FINDINGS

Mr. Arthur's assessment concerning T-hoppers was issued on February 7, 1986. The assessment reviewed the status of action plan activities that pertained to T-hopper concerns identified by the DOE. The DOE concerns were documented in the report DOE/OR-865 ("Investigation of T-Hopper Shipping Container Contamination") dated November 25, 1985 and a DOE letter dated August 29, 1985.

Mr. Arthur incorrectly identified the DOE Transportation Safety Appraisal Team that was at FMPC in February, 1986 and incorrectly concluded that he had attended the closeout which was held on February 14, 1986 and that the DOE team had only identified three items of concern. The DOE transportation team consisted of Messrs. Pryor and Slattery of DOE/ORO and Messrs. Cece and Sastry of DOE Headquarters. Mr. Arthur apparently attended an earlier meeting on February 12, 1986 but did not participate in other meetings or site field checks performed on T-hoppers by the DOE Transportation Safety Appraisal Team. A transportation safety appraisal report has not been issued; however, the February 14 closeout included the discussion of deficient areas. It was decided that WMCO should participate in a meeting with DOE and representatives from Paducah and Hanford to discuss inconsistencies and areas of concern. The multi-site meeting was scheduled and held on February 19 and 20 at Hanford.

Resulting from the DOE transportation team closeout with WMCO management and the DOE Site Manager, the FMPC DOE Site Manager placed a hold on T-hopper transport (Reafsnyder to President, WMCO, letter of February 14, 1986). The hold was not associated with the report of contaminated T-hoppers at Hanford on February 18, 1986, but the DOE Site Manager stated he continued the hold from February 14, 1986 because of this incident. WMCO (Britton to Reafsnyder, letter of February 27, 1986) discussed several items covered at the Transportation Safety Appraisal closeout and the Hanford meeting results. Additional information was to be provided in March. The DOE/FMPC Site Manager released the hold on March 3, 1986 (Reafsnyder to President, WMCO letter) and included comments pertaining to additional procedures and evaluations. WMCO (Britton to Reafsnyder letter of March 13, 1986) responded to the DOE letter of March 3, 1986.

No evidence exists that additional shipments of contaminated T-hoppers has occurred after the February 18, 1986 incident. The February 18, 1986 and the earlier July, 1985 incidents have been well publicized, investigated and reported.

Specific issues are addressed below:

1. There is no established periodic weight verification programs for assuring that the tare weight of T-hoppers or dollies have not changed over the years. (This was known by members of the transportation team.) Weighing of the T-hoppers at receiving and shipping is required with weighing information to be provided to the Nuclear Materials Reporting Clerk. Discussion with WMCO personnel indicate that differences in excess of 100 pounds receiver/shipper gross weight results in a check on individual case basis.

2. Tamper proof seals are not being used on the bottom closures. Tack welding of bolts on the bottom closure was being performed during the time of Mr. Arthur's February assessment. Tack welding was specified as an acceptable alternative to using tamper proof seals in a DOE memo (La Grone to Reafsnyder memo of August 9, 1985). The DOE/FMPC Site Manager (Reafsnyder to Pryor memo of September 24, 1985) reported that a tack welding program had commenced. Tack weld inspection is required and recorded on forms FMPC-PRO-862 and FMPC-PRO-862-1. Members of the DOE transportation team were aware that tack welding was being used in lieu of tamper proof seals. It is noted that no controlled tack welding maintenance procedure is in existence, although production procedures do require the bolts to be tack welded.

3. There are no maintenance procedures associated with leak testing or bottom gasket replacement. Production procedures do provide leak test instructions for all T-hoppers and notes that periodic (every 5 years) leak tests and bottom gasket replacement is required. Leak testing and bottom gasket replacement had commenced at the time of Mr. Arthur's assessment. This was known by members of the transportation team. A computer data system has now been established to keep track of gasket replacement and leak test dates.

4. WMCO does not perform leak tests on T-hoppers which are in the Paducah circuit. This was known by members of the transportation team. Discussions with personnel from Paducah indicate that the Paducah T-hoppers were refurbished and leak tested to 2 psig about three years ago. Paducah rechecked two T-hoppers per DOE requirements (La Grone to Jarmolow letter of August 9, 1985) after

the July, 1985 contaminated T-hopper incident. Paducah has not repreformed leak tests at 7 psig as WMCO has done due to the analysis performed by Rockwell for determining the maximum pressure generated in empty and full T-hoppers during possible extremes in ambient temperatures during shipping. The Paducah program should be completed in about 8 months. Final disposition of the Paducah T-hoppers has not been made at this time.

5. At the time of Mr. Arthur's assessment, ES&H procedures had not been issued for radiation surveys and visual inspections of incoming T-hoppers. These checks were being made during the assessment and a procedure was in preparation. This was known by members of the transportation team. Procedure ESH-P-30-004 (Survey of Radioactive Material Received or Shipped) was issued on 8/6/86. In addition, ES&H procedure ESH-P-30-003 (Survey of "T" Hopper at Plant 4) is being utilized as an interim procedure and is presently in the approval chain. Mr. Arthur's assessment does not indicate the ES&H procedure was flawed or vague but did recommend completion and issuance of the procedure (ESH-P-30-004).

6. There were recognized descrepancies in the washer sizes at the time of Mr. Arthur's assessment. This was known by members of the transportation team. This was resolved at the Hanford meeting later in February when a specific washer was selected and agreed to for use.

7. There was a procedure (4-C-804, Mobile Hopper Discharge Station and Packaging Depleted Green Salt) that included weighing, receiving and shipping inspection requirements for T-hoppers from Paducah at the time of Mr. Arthur's assessment. This was known by the transportation team.

8. There still remain procedures (specifically those associated with the scale identified in Mr. Arthur's assessment) which need to be reviewed and updated to reflect scale 4-44's operation. Discussions would indicate maintenance had not received a copy of the assessment nor had a formal follow-up to the assessment been provided. A response to the assessment had not been requested but production personnel had reviewed the assessment for their action.

9. Specifications for the bottom gasket were added to the drawing after the assessment.

10. The July, 1985 contaminated T-hopper incident involved leakage from within the T-hopper. Interim actions (La Grone to Reafsnyder memo of August 9, 1985) were required. No evidence exists that other T-hopper shipments have incurred this type of leakage. Another contaminated T-hopper incident occurred on February 18, 1986 but the investigation (Simonson to Hansen, letter of April 3, 1986) revealed the source of contamination was external to T-hopper. Actions were taken and procedures were changed to specify time requirements prior to shipments. No evidence exists that additional contaminated T-hopper shipments have occurred.

11. Mr. Arthur's assessment was not provided to the transportation team. The DOE Transportation Team was told that the T-hopper situation had been under evaluation and that several items remained to be worked such as specifications, washer sizes, etc.

QA surveillances on T-hopper shipments commenced in March, 1986. Several surveillances have been performed to date.

Action to upgrade T-hopper shipment resulting from the commitment arrived at during the Hanford meeting has been documented (Britton to Reafsnyder letter of June 19, 1986). These improvements include the development of a document which will include uniform inspection, maintenance and operational practices and procedures among Fernald, Hanford and Paducah. The transportation team knew that this topic would be discussed at the Hanford meeting where a designated custodian of the T-hoppers would be selected.

CONCLUSION

It is a matter of record that two contaminated T-hoppers shipments occurred between July, 1985 to February 18, 1986. There is no evidence that reoccurrence of contaminated shipments continued after February 18, 1986. It is recognized that procedural updating and issuance is still required and that the document being prepared by WMCO should include and identify needed procedures. It is also concluded that some of Mr. Arthur's concerns such as lack of maintenance procedures were misunderstood by WMCO and therefore should be re-reviewed in this light. The team could not validate that implementing Mr. Arthur's recommendations would have prevented the February 18 contamination incident because his assessment did not indicate the ES&H procedure was flawed or vague and only recommended completion and issuance of the procedure.

A procedure titled "Mobile Hopper Discharge Station and Packaging Depleted Green Salt" included the inspection, weighing and shipping instructions for the Paducah T- Hoppers prior to Mr. Arthur's assessment. The team also concludes that there is no evidence of WMCO attempting to conceal information from DOE but does believe that communication between Mr. Arthur and other WMCO personnel could have been improved.

RECOMMENDATIONS

It is recommended that WMCO, as the T-hopper custodian, evaluate the need to test the Paducah loop T-hoppers to 7 psig and determine final disposition of T-hoppers in the Paducah loop.

It is also recommended that there be more participation of Paducah and Hanford personnel in the preparation of the T-hoppers guidance document which is scheduled to be drafted by the end of this year.

ISSUE NO. 8: ES&H IMPLICATIONS OF ALLEGED PROHIBITION OF AUDITS OF PLANT SCALES; ADEQUACY OF PROCEDURE FOR PLANT 5 SCALES

o AFFIDAVIT; PAGE 5

> "In my audit of the scales used at Fernald, which are important for measuring materials and discovering discrepancies, I was restricted to auditing Plant 5 scales only, where I found a widespread breakdown in compliance with procedures."

o RESIGNATION LETTER; PAGE 2

> "Several scales that in use for weighing uranium material are not included in a Preventive Maintenance Program."

FINDINGS

Mr. Arthur's QC audit on Plant 5 scales was issued on July 31, 1985. As a result of the QC audit, the Materials Control and Accountability (MC&A) Section agreed to perform a survey of the remaining accountability scales during August and September, 1985. The MC&A survey resulted in similar findings and was issued in December, 1985. Findings included such items as: procedures needed revision and were not available at the proper weighing stations; scales listed in SOP's were out of service or had been replaced; labeling was needed on scales/checkweights, etc. It should be noted that the MC&A survey did not include a review to assure scales were in the Preventive Maintenance (PM) System.

No follow-up has been performed by MC&A, although they plan to perform a review of the scales by end of this calender year. The MC&A group does review monthly reports which indicate scale accuracy. One scale was checked by taking samples from previously weighed lots and compared. Readings were within accepted reading tolerances.

Follow-up of the QC scale audit was conducted on November 20, 1985, and indicated several items were still in need of resolution. The October 9, 1986 audit status report indicates the QC audit is still under QA follow-up verification.

CONCLUSION

The MC&A survey validated that improvement and updating of procedures was needed. The team could not validate that Mr. Arthur was restricted to auditing Plant 5 scales for any devious purpose.

RECOMMENDATION

All scales should be checked to see if they are in the Preventive Maintenance System and are properly labeled since this was not done during the MC&A survey.

ISSUE NO. 9: ADEQUACY OF PROCEDURES, FAILURE TO FOLLOW PROCEDURES FOR "DERBY BREAKOUTS"

o AFFIDAVIT, PAGE 7

> "...in an audit on "Derby Breakouts", dated November 11, 1984, I identified many significant violations of the procedure. For one, the procedures were not current, did not reflect the operations as performed, were not even available in the work areas, and left out important health and safety requirements, such as the requirements for respirators in high radioactive dust areas. Even though management agreed with the problems identified in the audit, and promised corrective action in a March 23, 1985 response (three months late), a follow-up audit performed by myself eight months later found that none of the promised corrective actions had been implemented."

FINDINGS

The subject audit report (QCA 3.89) was issued on November 12, 1984 and contained twenty audit items requiring resolution. Of these twenty items, only one item refers to the violation of an existing procedural requirement. Most of Mr. Arthur's audit findings call for additional procedural requirements but do not indicate the violation of existing procedures.

Mr. Arthur's own audit finding was that "current revisions of SOP 5-C-104 were posted at the East and West Breakout Stations of [the] audited area" (Summary, QCA 3.89). Further, Mr. Arthur's contention that "procedures were not current" could not be substantiated. Standard Operating Procedure 5-C-104, "Derby Breakout," was reissued on March 3, 1982. Revisions to this procedure were made on May 10, 1982 and on June 10, 1983. Since the procedure had been revised as recently as one year before Mr. Arthur's July, 1984 audit (the audit was conducted four months before the issuance of the November 12, 1984 audit report), the procedure was, for practical purposes, "current." With one exception, there is no evidence that derby breakout operations in July, 1984 deviated from the existing SOP.

The team found that SOP 5-C-104 did address important health and safety requirements. At the time of Mr. Arthur's audit, there were ten industrial safety requirements listed in the SOP. Included with these requirements was the statement: "A dust respirator will be worn when dusty conditions are encountered." This requirement has been in effect at the derby breakout stations since March, 1982 and possibly earlier. (The DOE believes that respiratory protection requirements should be explicitly stated in operating procedures and that mandatory respirator requirements should not be open to interpretation. See Issue No. 3.) In his audit report, Mr. Arthur expressed concern that respiratory protection was not specifically required per SOP 5-C-104 when "wet pots are being discharged." Preliminary air sampling data collected during this operation do not indicate that mandatory respiratory protection should be required based on WMCO guidelines.

On March 23, 1985, Production responded to Mr. Arthur's derby breakout audit. As part of his audit report, Mr. Arthur had rewritten SOP 5-C-104 to incorporate the comments and recommendations in his audit report. Production agreed with the rewrite of the SOP; however, several exceptions to Mr.Arthur's rewrite were noted. On August 15, 1985, three months before Mr. Arthur's audit follow-up, the QA/QC Procedures Group issued a revised version of SOP 5-C-104. In Mr. Arthur's November, 1985 audit follow-up (QCA 3.89F), it states:

> "As of the date of this Follow-up, a Change Request to revise the procedure to the rewrite (Mr. Arthur's rewrite of SOP 5-C-104) has not been received by the Procedures Group."

It is true that Mr. Arthur's rewrite was not used for the 8-15-85 revision of SOP 5-C-104. Several of the changes recommended in his audit report, however, were incorporated into the revision. Production believed that Mr. Arthur's rewrite had been submitted to the Procedures Group prior to the 8-15-85 SOP revision. This was not the case.

CONCLUSION

Mr. Arthur did not identify "significant" procedural violations during his audit of derby breakout operations. His audit report contained some good recommendations for additional requirements, and some of his recommended changes should be incorporated into the SOP. The former SOP did not leave out important health and safety requirements.

RECOMMENDATIONS

WMCO should review Mr. Arthur's rewrite of SOP-5-C-104 and make appropriate additions to the current (8-15-86) version of the SOP.

ISSUE NO. 10: ADEQUACY OF PERSONNEL RADIATION MONITORING PROCEDURES AND EQUIPMENT

o AFFIDAVIT; PAGES 8 AND 9

> "To my knowledge, until about nine months ago (mid-1985) there was not one state-of-the-art piece of radiation monitoring equipment for general personnel. It was never standard procedure to require such monitoring as well. I saw only one hand-held radiation monitor in use at the plant, and two broken monitors that were never used. It was not standard to screen personnel either coming or going at Fernald. New monitoring equipment was installed in the summer of 1985, in my opinion, thirty-three years too late."

FINDINGS

Until recently, the radiation instrument inventory at the FMPC has been small. Routine personnel contamination monitoring did not begin until 1985. Prior to this time, instruments were used exclusively by the health and safety staff. Because this staff was small, there was little demand for radiation instruments. In 1984, there were only two health physics professionals at the FMPC, and there were approximately 35 radiation instruments in use (excluding area alarm monitors and air samplers). Currently, the FMPC employs ten health physics professionals. The current radiation instrument inventory totals approximately 250 instruments including 16 hand and foot monitors and 70 personnel contamination friskers. Thirty percent of the new personnel contamination monitoring equipment has been deployed and is now routinely used by WMCO employees when they egress from contaminated areas of the plant. The remaining instruments will be deployed when new contamination control points are identified.

Mr. Arthur's statement that personnel were not screened for contamination prior to 1985 is correct. However, instruments used by the health physics staff during Mr. Arthur's period of employment were state-of-the-art (i.e., solid state; current vendor issue). There may have been no evidence of these instruments in the plants during Mr. Arthur's tours and audits as their use was limited to health and safety personnel. The two "broken monitors" referenced in Mr. Arthur's allegation were probably those excessed from NL Industries' Albany, NY plant. Because of maintenance problems, these instruments were never successfully deployed at the FMPC.

CONCLUSION

Mr. Arthur's statements have been verified in that personnel contamination monitoring equipment was not available at the FMPC until 1985. WMCO has taken steps to provide extensive personnel contamination monitoring facilities throughout the plant since assuming the FMPC contract. Personnel monitoring equipment is now readily accessible to the general plant population, and self-monitoring is a mandatory requirement.

ISSUE NO. 11: RISK OF CRITICALITY ACCIDENT AS A RESULT OF NOT FOLLOWING MANUFACTURING SPECIFICATIONS (MS'S)

o AFFIDAVIT; PAGES 10 AND 11

> "In the area of auditing Manufacturing Specifications (MS's), I found that NLO had only performed six audits in the entire lifetime of the plant. It is extremely important that MS's are followed. A possible result of failing to follow an MS is that a nuclear criticality accident could occur."

FINDINGS

A criticality accident involving the uranium materials processed at FMPC is possible. While the possibility does exist, the probability is considered to be remote. Where uranium metal at U-235 enrichments below 5% are involved, no criticality is possible without moderation. The specific conditions for criticality would involve large uranium masses, unique spacing, and reflection in addition to moderation. For other uranium material in this enrichment range, the conditions are also narrow in scope. For the limited uranium materials above 5% U-235, special attention is given by FMPC to prevent criticality.

WMCO has a nuclear criticality safety (NCS) staff which reviews and approves the MS's. In the past two years, the nuclear criticality safety staff has performed 127 criticality safety inspections in production areas. As a result of these inspections, 73 infractions of Manufacturing Specifications were reported. None of these infractions were serious nor could have resulted in a criticality accident. The infractions were reported in order to maintain a wide margin of safety per DOE Orders.

The QA/QC Procedures Group during Mr. Arthur's period of employment with the FMPC was responsible for auditing compliance with Standard Operating Procedures (SOP's). Compliance with MS's were only reviewed as they pertained to specific SOP's. It is not possible to determine the number of MS's that have been audited at the FMPC in the history of the plant due to incomplete records.

CONCLUSION

The nuclear criticality safety staff performs inspections in the production plants and documents infractions of Manufacturing Specifications. The number of MS audits conducted by the Procedures Group in the history of the plant cannot be determined. The fact that the nuclear criticality safety staff has historically performed inspections and reported infractions of MS's indicates that mechanisms have existed to assure adequate NCS compliance independent of Procedure Group audits.

ISSUE NO. 12: PROBLEMS WITH PROCEDURES FOR PROCESSING "PLUTONIUM OUT OF SPECIFICATION (POOS)" MATERIALS

ISSUE NO. 12A: IMPROPER PROCESSING OF PLUTONIUM CONTAMINATED ASH RECEIVED IN 1980, AND PROCESSED IN 1982

o TESTIMONY TRANSCRIPT; PAGE 9

> "...Fernald had received a shipment of plutonium-contaminated ash in 1980, and had processed a portion of that plutonium-bearing materials in a manner which jeopardized the worker's health and safety. A September, 1985 DOE investigation of Fernald's handling of the plutonium-bearing material in the past was highly critical, and serves as background information for this incident."

o AFFIDAVIT; PAGE 28

> "...Fernald had received a shipment of plutonium-contaminated ash in 1980, and had processed a portion of that plutonium-bearing material in a manner which had jeopardized the workers' health and safety. A September, 1985 DOE investigation report of Fernald's handling of plutonium-bearing material in the past was highly critical, and serves as background information for this incident."

o TESTIMONY TRANSCRIPT; PAGE 9

> "Plutonium-bearing materials containing more that 10 parts per billion (PPB) require special handling, including the use of protective equipment, respirators, constant air monitoring, routine worker exposure analysis and strict adherence to quality control/quality assurance procedures. In 1982, Fernald had processed plutonium-bearing materials of up to 7,757 parts per billion without observing any safeguards. The September 1985 DOE investigation was highly critical of this practice."

o AFFIDAVIT; PAGES 28 AND 29

> "Plutonium-bearing materials containing more than 10 parts per billion (PPB) require special handling, including the use of protective equipment, respirators, constant air monitoring, routine worker exposure analysis and strict adherence to Quality Assurance/Control procedures. These requirements were established by a DOE directive of April 4, 1985, and adopted internally by NLO in March of 1985. Apparently, previous to this commitment, NLO had considered that materials containing 20 parts per billion or more of plutonium required special procedures. In 1982 Fernald had processed plutonium-bearing materials up to 7,757 parts per billion without observance to any of these safeguards."

) AFFIDAVIT; PAGES 29 AND 30

"According to the September 1985 DOE investigation entitled, "The Report of the Joint Task Force on Uranium Recycle Materials Processing", the Fernald facility:

- Did not keep accountability records of transuranic and fission products elements it worked with. As such, "the Task Force could not determine, with confidence, the quantity of contaminants that may have been received and processed at the FMPC. Only best estimates were available for review."
- It could not be established by the Task Force that DOE formally knew of the plutonium levels in the ash, which ranged from 67 parts per billion (ppb) to 7,757 ppb. About 168 metric tons of plutonium-bearing material currently remains at FMPC in the form of uranium trioxide. Special precautions will need to be taken to process this material.
- The Task Force concluded that "insufficient effort and attention was given to worker safety and radiation exposure control. For example, during routine operations the decision on whether an ingestion of radioactive material has taken or could take place rests with the worker. It did not appear to the Task Force that workers have had enough training and/or knowledge to intelligently make such decisions."
- Deficiencies in the Fernald's Health Physics and Environmental Programs were noted by the Task Force."

FINDINGS

Report No. DOE/OR-859, entitled, "The Report of the Joint Task Force on Uranium Recycle Materials Processing" was published in September, 1985. With regard to the statement that the 1982 Paducah Feed Plant ash campaign at FMPC was carried out "in a manner which jeopardized the worker's health and safety," specific findings of the joint task force read as follows:

> Page ix:
>
> "The recycle material that is produced by the reprocessing sites can be safely handled and further processed by the intermediate processing sites (ie. FMPC) if a clear understanding of the contaminant levels exists and available technology (where needed) is utilized to assure environmental, safety and health protection of both the plant worker and the general public. Historically, the Task Force noted that a formal understanding of the contaminant levels was not always apparent as evidenced by the lack of formal specifications on maximum permissible contaminant levels between the reprocessing, intermediate, and customer sites.... Although the intermediate processing sites may not have had a formal understanding of contaminant levels in recycle materials, sufficient information was available and/or developed to permit the further processing of recycle materials in a manner that did not jeopardize or compromise the

> environment, safety or health of the worker or the public as best can be judged by the Task Force. It should be made clear that only very limited information and data were available from historical records to: (1) characterize the level of contaminants received from the reprocessing sites; (2) examine the full extent of methods implemented to protect the worker's health and safety; (3) examine the flow of contaminants during processing operations; and (4) characterize the ultimate fate of the contaminants."

Further commentary on this issue specific to the FMPC operations appeared on page 37 of the report:

> "Worker protection could have been much better. For example, workers should have been better informed. The NLO-FMPC Manufacturing Standards/Procedures (November 17, 1982, revised January 7, 1985) mention only briefly the need for air-purifying respirator with purple radionuclide cartridges when dusty conditions exists. The standard also appears to place the burden of deciding whether or not a significant uptake of radionuclides has occurred (and thus the need for urine analysis) on the employee.
>
> Overall, additional environment, safety and health management attention and involvement is required. There is a need for better respiratory protection, housekeeping practices, and radiation protection and control practices at FMPC. The need for operator education, especially when working with materials in excess of 10 ppb plutonium, exists as does the need for meaningful operator training."

Other information on page 37 reports on the 1985 follow-up plutonium burden measurements for four of the FMPC workers that participated in the 1982 processing campaign, all of which were negative.

The 1982 POOS materials campaigns were carried out prior to the establishment of the 10 ppb control criterion, or any other specific POOS crieria. The 20 ppb number was an internal guideline used by NLO to determine if any nonroutine evaluations of material handling procedures might be necessary because of elevated plutonium levels.

An examination of the record yielded some documentation concerning enhanced health and safety measures for the 1982 POOS material campaign. Former NLO personnel involved with the processing indicate the Paducah Feed Plant ash material was blended with noncontaminated feed (little or no Pu) to levels which ensured that the Uranium fraction would be controlling factor relative to personnel exposure. This Pu contamination level was nominally higher than 10 ppb. Process materials were then handled according to normal procedures. During the blending operations, workers wore supplied air respirators and several continuous air samplers were set up in the work area.

The April 4, 1985 DOE directive read as follows:

> "No materials containing $\geq$ 10 ppb Pu, on a uranium basis are to be processed at the FMPC unless specifically approved in writing by my office.
>
> Requests for DOE approval of exceptions to this requirement should detail the need for processing such material, the source of the materials to be processed, special in-plant procedures to be implemented during processing and the impact such processing may have on workers and the environment."

Neither this letter nor NLO's internal adoption of the 10 ppb criterion in March, 1985 would indicate NLO conducted the 1982 POOS material campaign in contravention of any definite procedural requirements.

CONCLUSION

No specific operational requirements were defined for POOS material processing at the time the Paducah Feed Plant Ash was delivered to the FMPC in 1980, or when part of this material was processed in 1982. Previous DOE evaluations of the 1982 operations cited a lack of data and information and concluded that worker protection measures could have been better; but reported no definite evidence that the 1982 campaigns jeopardized the health and safety of the workers.

ISSUE 12B: ADEQUACY OF HEALTH AND SAFETY PROTECTION MEASURES FOR 1986 POOS MATERIALS CAMPAIGNS

o TESTIMONY TRANSCRIPT; PAGE 11

> "Worker health and safety is important to me, as a worker, and I was helplessly watching Westinghouse try to rush through procedures that would not do the job."

o RESIGNATION LETTER, PAGE 3

> "Fernald Site has recently been granted special permission to process out-of-specification plutonium-bearing uranium. New and revised procedures at the Fernald Site do not include adequate information for the overall operation of processing out-of-specification plutonium-bearing uranium."

o AFFIDAVIT; PAGE 29

> "Westinghouse was planning to process more of this material (POOS) in response to pressure from Hanford, in order to alleviate a shortage of greensalt that was about to develop. The plans called for processing appoximately (sic) 168 metric tons of uranium oxide containing an unknown level of plutonium contamination, as well as some raffinate containing, according to a November, 1985 report, up to 3,500 ppb..."

FINDINGS

A February 7, 1986 letter from the DOE Site Manager to WMCO contained the following statements:

> "DOE-HQ has reviewed the referenced plans to process FMPC materials that contain more than 10 ppb of plutonium. Conditional concurrence has been received to (a) process the approximately 168 MTU of UO_3 (reference 3), and (b) filter and dry refinery raffinates (reference 2). The conditions upon which DOE concurrence was obtained are shown in attachment 1 to this letter. The management plans (references 2 and 3) and attached conditions constitute the actions that should be taken by WMCO to process UO_3 and refinery raffinates....
>
> ....Please advise when the preparations supporting the processing of UO_3 and refinery raffinates have been completed and WMCO is prepared to initiate the processing of these materials. At that time my office will conduct a preoperational readiness review prior to DOE authorization to proceed."

Attachment 1 to the February 7, 1986 letter contained the following special conditions, all of which related to the protection of the worker's health and safety:

"1. Plutonium shall be considered the controlling radionuclide for operations involving filtering and drying of raffinates. Accordingly, the concentrations guide for plutonium as defined by DOE Order 5480, Chapter XI, Attachment I, shall be used.

2. The concentration guide for the processing of UO_3 may be calculated using the methodology for mixtures of radionuclides in DOE Order 5480, Chapter XI, Attachment 1. However, as the ratio of plutonium to uranium is not consistently known during processing, the concentration of plutonium shall be assumed to be twice that of composite sample having the highest transuranic (TRU) content. Composite samples should be analyzed with sufficient frequency to assure assumptions made with respect to TRU content have not changed. Documentation of the analysis and assumptions used to determine the concentration guide should be maintained.

3. With respect to air monitoring, the investigation level for all operations involving more than 10 ppb plutonium on a uranium basis shall be one Maximum Permissible Concentration (MPC). Prolonged exposures at or above an MPC should not be permitted.

4. Protective clothing (e.g., booties, coveralls, respirators, etc.) used in exclusion work areas shall be disposable or be restricted from use in other plant operations. Additionally, laundry used in exclusion work areas will be clearly separated from laundry in other operations.

5. In addition to the urinalysis program defined in the management plans, an analysis for plutonium/neptunium shall be done at the conclusion of the UO_3 campaign (understood to be about six months), and at a six month frequency for the refinery raffinate operations. Analysis for plutonium/neptunium should also be performed for samples obtained prior to the operations to obtain baseline data and should be considered during investigations of any abnormal exposure incidents. Periodic nasal smears should be acquired and analyzed.

6. Trend analysis for both the air monitoring and nasal smears for removable contamination should be performed at a sufficient frequency to detect a trend toward elevated concentrations of contaminants.

7. Exclusion work areas shall be cleaned daily. This will require that an exclusion work area be established for the refinery raffinate operations."

The 3500 ppb contamination level figure cited in the affidavit is relative to the uranium fraction in the raffinate. U is less than 0.1% of the raffinate, indicating the Pu fraction in the aggregate raffinate would be less than 3.5 ppb.

CONCLUSION

The preparations for the POOS material campaigns took considerably more time than may have been expected by WMCO in early 1986. The Plant 8 processing of the raffinates did not actually proceed until mid 1986, after an extensive WMCO preoperational review, followed by a DOE "readiness review." The documented record indicates that the protection of the worker's health and safety was the primary issue that required resolution prior to initiation of the POOS materials campaigns.

ISSUE NO. 13: NONCOMPLIANCE WITH WATER TREATMENT REQUIREMENTS

ISSUE 13A: WATER PLANT SOP DEFICIENCIES

o AFFIDAVIT; PAGE 15

> "The treatment of water at Fernald includes sampling and testing, preventing uranium losses to the environment via water channels, the treatment of water for plant personnel consumption, sanitary sewage disposal, testing fire pumps, water sampling and testing from the chemical pits and more. The objective of the audit was to "evaluate the operation of the Water Plant and verify that current operations and inspection practices are in compliance with authorized procedures.
>
> During my audit, I found massive noncompliances. I identified 14 procedures that should have been referenced in the Standard Operating Procedure (hereinafter, "SOP") that were not referenced. I also found inconsistencies with what the SOP called for and the actual practice."

FINDINGS

In November, 1984, Mr. Arthur conducted an extensive procedural audit of the water utilities operations at FMPC. A report was published on January 31, 1985; QCA No. 4.02, with the audit subject: Operation of the Water Plant (water treatment and Site wide responsibilities). The audit report included 55 specific findings that required formal resolution as part of the audit procedure. Most related to inconsistancies between out-of-date procedures and actual operation practices, or suggested additions to the procedures to more completely describe operations. A response to the audit was submitted on February 16, 1985 that effectively resolved all of the specific findings except one. By December 30, 1985, all audit items had been resolved.

One of the findings in the audit noted that 14 reference procedures were required to cover all of the water plant and "site wide" responsibilities and that these reference procedures needed to be added to the general SOP. This was done and the audit finding was resolved.

CONCLUSION

Neither Mr. Arthur's finding that the 14 reference procedures needed to be added to the general SOP, nor any other of the audit findings documented any operational problems that might be construed to be noncompliances with ES&H regulations or guidelines.

ISSUE 13B: ADEQUACY OF "ROUTINE" OR "DAILY" INSPECTIONS; WATER PLANT OPERATIONS

o AFFIDAVIT; PAGE 15

> "Several operations listed in the SOP, which called for routine daily checks by operating personnel, were not performed either "routinely" or "daily."

FINDINGS

Audit Report QCA 4.02 contained the following specific finding:

> "Several operations listed in paragraph "Routine Daily Checks by Operating Personnel," are not "routine" or "daily" operations. The paragraph "Routine Daily Checks by Operating Personnel," should be revised to better define the operations listed. An example for a heading may be, Site Wide Operations."

This finding had been resolved by the time of the follow-up.

CONCLUSION

The team found no evidence to conclude that operation checks were not being performed as required, or were being performed less frequently than necessary.

ISSUE NO. 13C: FROZEN WATER SAMPLES

o AFFIDAVIT; PAGES 6 AND 7

> "In an audit of the water testing procedures at Fernald in late November, 1985, I discovered that many of the water samples were brought to the laboratory frozen solid."

o AFFIDAVIT; PAGE 16

> "I also observed that some samples would be brought into the Water Plant Laboratory frozen solid."

FINDINGS

Audit Report QCA 4.02 contains the following specific finding:

> "It was found during the audit that some samples would be brought into the Water Plant Laboratory frozen solid. In order to avoid this problem, it is recommended that some form of an enclosed insulated carrying rack be used. (Refer to Item 50 of this audit report.)"

CONCLUSION

The water utilities manager and his staff conferred on this matter and, collectively, could not recall any instance when water samples were actually delivered to the laboratory completely frozen. Some samples collected during cold weather (i.e. perhaps at the time of the audit in late November) could conceivably have ice mixed with the sample. The presence of ice in the samples, or even completely frozen samples, would not be unacceptable for most of the analyses performed at the Water Plant laboratory. Exceptions might be those tests for fecal coliform, total coliform and BOD. Water samples are now being transported in insulated coolers containing cold packs that maintain samples at about 4°C regardless of weather conditions.

ISSUE NO. 13D: ADEQUACY OF OPERATIONAL PROCEDURES FOR CHEMICAL PITS

o AFFIDAVIT; PAGE 15

> "The steps for operations in the Chemical Pits failed to mention how often the prescribed operations are to be performed, how often the flow charts are to be changed, and that samples of the effluent are taken for analysis."

FINDINGS

Audit Report QCA 4.02 contains the following specific finding:

> "Steps 6.2.41 and 6.2.42 which are operations for the Chemical Pits should be in a subparagraph ("Chemical Pits"), with a reference made at the beginning of the "Steps" to SOP 43-C-601, Chemical Pits. Also the "Steps" do not mention how often the described operations are performed, and that samples of the effluent from the Chemical Pits are taken peridically for analysis. (Refer to Table 43.1, Item 20.)"

CONCLUSION

The procedures have been revised to include the information the audit report recommended be added. This deficiency in the operating procedures did not constitute or create an environmental risk.

ISSUE NO. 13E: ADEQUACY OF PROCEDURES FOR CERTAIN WASTEWATER TREATMENT FACILITIES

o AFFIDAVIT; PAGE 16

> "Several problems as noted above were also problems for the Sewage Treatment Plant, the Ultra Violet Treatment Facility, the Manhole 175 Area, the Check of Manhole pH Meters and Alarms, and other areas audited."

FINDINGS

Audit report QCA 4.02 contained the following specific findings:

> "Steps 6.3.1 thru 6.3.25 which are operations for Sewage Treatment, should be in a subparagraph ("Sewage Treatment"), with a reference made at the beginning of the "Steps" to SOP 43-C-501, Sanitary Sewage Treatment Plant. Also the "Steps" do not mention how often the described operations are performed, and that samples of the sewage are taken periodically for analysis at different treatment stages. (Refer to Table 43.1, Item 16.)"
>
> "During the audit it was observed that sewage effluent was being sent through and Ultra Violet Treatment facility, with samples of the effluent being taken periodically for analysis. Information on the Ultra Violet Treatment facility should be added to the SOP, in conjunction with Steps 6.3.1 thru 6.3.25."
>
> "Steps 6.4.1 thru 6.4.10 of subparagraph "Manhole 175 Area," does not mention how often the charts are changed, or about all the samples of the effluent that are taken periodically for analysis. (Refer to Table 43.1, Item 17.)"
>
> "Subparagraph "Check of Manhole pH Meters and Alarms," should have references added at the beginning of the subparagraph to SOP 43-C-308, Responding To Indications Of Out-Of-Specification At Manholes 12, 14, 22 and 23, and SOP 2-C-914, Preventing Uranium Losses Through Storm Sewer To Environment (Responding to pH Alarms)."
>
> "Steps 6.6.1 thru 6.6.4 of subparagraph "Check of Manhole pH Meters and Alarms," does not mention that samples of the effluent from the manholes are taken periodically for analysis, (Refer to Table 43.1, Item 17.)"

CONCLUSION

The procedures have been enhanced and updated to include the information recommended. No operational deficiencies or environmental protection risks were implicit to any of the audit findings.

ISSUE NO. 13F: CROSS CONTAMINATION OF WATER SAMPLES

o AFFIDAVIT; PAGE 16

> "I noted that several samples (including water and seage (sic) sludge samples) were placed into one carrying rack that did not contain divided compartments. As a result, the samples would tip over and intermix with, and leak onto other samples in the carrying rack."

FINDINGS

The plastic bottles used for sample transport have screw type caps which, if on tight, do not leak.

CONCLUSION

NLO/WMCO's handling and transport of water samples is consistent with normal practice.

Significant leakage of water sample containers, possibly resulting in cross-contamination of samples while in transport, is not a routine problem.

ISSUE NO. 13G: ADEQUACY OF H_2SO_4 STORAGE AT CLEARWELL

o AFFIDAVIT; PAGE 31

> "During the audit, I observed that sulfuric acid spilled from the acid storage tank while the acid tank above the clear well was being charged with acid. The acid was contained in the concrete basin, but quickly leaked out through the bottom. Also, the acid tank above the clear well rested on a severely warped piece of plywood. I wrote: "If this board warps enough or breaks, the acid tank could tip and spill acid out. It is recommended that a thorough inspection be made of the structure."

FINDINGS

At the time of the audit, the spill containment basin beneath the sulfuric acid storage tank was in a poor state of repair. It has since been restored. The warped piece of plywood has been removed and replaced with a steel plate. The plywood was not part of the support structure for the clear well acid tank.

CONCLUSION

The spill containment structure for the acid tank needed to be repaired, and it was. The warped plywood has also been replaced.

ISSUE NO. 13H: ADEQUACY OF WATER PLANT LABORATORY PROCEDURES

o AFFIDAVIT; PAGES 17 AND 13

> "During the audit I found several non-compliances. The measurements of chemicals used for testing samples were inconsistent with the measurements listed in the operating procedure. Several tests listed in the procedure were not performed at all, and several tests that were performed were not listed in the procedure. Information on what chemicals were to be mixed together to perform many of the tests were also not listed in the procedure."

FINDINGS

Audit Report QCA 4.03 (Water Plant Laboratory Procedures) contained a number of specific findings concerning deviations of actual practices from the procedure descriptions, the lack of sufficient detail in the procedures, and the use of imprecise terms in the procedures. Several examples of such specific findings are as follows:

> "Paragraph 2.12, segment "Reagents" states, "10% Ascorbic Acid - Weigh 5 grams of reagent grade L - ascorbic acid and ...." During the audit it was found that 5% ascorbic acid is used as a reagent."
>
> "The seventh paragraph of this section that covers miscellaneous testing, does not include the testing of lime. (Refer to Table 305.1, Item 23, for information found during the audit.)"
>
> "Step 1.7.4 states, "Add 1 full dipper of sulphite indicator (Betz Code No. 219) and mix." The volume of the "full dipper" is not included in the SOP."

Follow-up documentation on this audit indicates new procedures were written to resolve all of the audit findings.

CONCLUSION

The audit findings did not identify analytical technique noncompliances, nor did the team identify a problem in this area. Similarly, the laboratory is currently performing all required operational analytical functions.

ISSUE NO. 13I: ADEQUACY OF RECORDS FOR CHEMICAL SHELF LIFE

- AFFIDAVIT; PAGE 18

> "No records were kept for the length of time chemicals were stored to evaluate the stability of the chemicals."

FINDINGS

Audit Report QCA 4.03 included the following specific finding:

> "It would be helpful to the Technician to have a "Table" included in the SOP, referencing the preparation of reagents, the type of containers used for storing, and the length of time the reagents are stable."

Laboratory procedures have been revised to resolve the audit finding. However, these procedural changes do not include the maintenance of records to specifically track shelf life.

CONCLUSION

The water plant laboratory analytical tasks are not of such scope and diversity to suggest a shelf life tracking procedure is really necessary. Standards analyses are run quite frequently for most of the analytical procedures being used which would usually detect any significant accuracy or precision problems caused by off-specification reagents.

ISSUE NO. 13J: ADEQUACY OF TDS SAMPLING PROCEDURE FOR SEWAGE SAMPLES

o AFFIDAVIT; PAGE 18

> "During the audit I observed that samples of sewage treatment waste were placed in a small, unventilated furnace set at 600 degrees Fahrenheit for over an hour. The object of the test was to determine total dissolved solids. Due to the dense smoke and strong, offensive odor that was created, all personnel had to evacuate the laboratory room. Later with the door open to let out the smoke, I entered the laboratory room and found smoke residue on supposedly sterile equipment. When I informed Mr. Tippenhauer of my experience, I was told not to include information in the audit about finding the smoke residue on the sterile lab equipment."

FINDINGS

Audit Report QCA 4.03 included the following specific finding:

> "Currently, the Water Plant Laboratory performs Total Dissolved Solids Volatile, and Total Suspended Solids Volatile tests on collected samples of primary settling basin sludge, raw sludge, recirculated sludge, and ultra violet treatment effluent, of the Sewage Treatment Plant. During the audit it was found that when the samples were placed in the muffle furnace set at 600°F. personnel had to evacuate the Laboratory room, due to the dense smoke and strong odor that was created. (Presently, the muffle furnace does not have a vented hood.)"

Mr. Arthur's description of the operation of the muffle furnace at the time of the audit is accurate.

CONCLUSION

This matter was referred to a Health and Safety Division staff member, who recommended the muffle furnace be relocated under the ventilation hood in the lab. This had been accomplished by December, 1985.

The equipment on which Mr. Arthur may have viewed smoke residue was not intended to be stored in a sterile state. Such equipment must often be used in a sterile state, however, and part of the operating procedure in the laboratory called for the autoclave sterilization of such equipment immediately prior to use.

ISSUE NO. 14: DISCONTINUATION OF URANIUM AND OTHER MONITORING AT SHALLOW TEST WELL NO. 1

o AFFIDAVIT; PAGES 15 AND 16

> "...contrary to the SOP, Test Well No. 1 Shallow was no longer sampled for uranium or other contamination. Even the pump had been removed from the well. Upon inquiry, I was told that uranium levels in the well were too high, and therefore testing on that well was no longer done."

FINDINGS

A review of the record indicates that Test Well No. 1 Shallow, designated T1S in environmental monitoring locations and other documents, was installed in the early 1960's and, until June, 1984, was pumped continuously at approximately 120 gallons per minute (approx. 175,000 gal/day or 0.175 MGD). During the period of time the older waste pits were being used, elevated levels of nitrate, chloride and other chemical processing constituents, including uranium, were found in the water pumped from T1S. Process waste constituent concentrations in T1S samples decreased after closure of the old pits and, by early 1984, chemical parameters were near normal background levels. Uranium levels remained elevated, although not as high as in earlier years.

It was believed for many years by FMPC operations management personnel that the continuous pumping of T1S created a hydrologic cone of depression in the waste pit area and effectively intercepted a significant component of the downward gradient of heavily contaminated groundwater that could, if left unchecked, impair the quality of water in that portion of the general aquifer servicing the plant's water supply production wells. In 1983 and 1984, Dames and Moore was contracted to study groundwater contamination problems at FMPC. Although not part of their study contract, FMPC plant operations personnel questioned the Dames and Moore staff about the relative merits of continuous pumping at T1S. On June 19, 1984, a Dames and Moore expert informally advised that, because the transmissivity of the shallow strata of the pit area is relatively high, and the chemical constituant concentrations in the water being pumped are sufficiently low, and because the production well aquifer is hydrologically isolated from the pit area; he did not believe continuous pumping at T1S resulted in any appreciable environmental or health protection benefits. FMPC operations personnel discontinued continuous pumping shortly thereafter.

After continuous pumping operations were suspended, the T1S pump was only operated for operational or environmental monitoring sample collection purposes. An examination of the WMCO H&SD sampling and analytical record for T1S since January, 1982 yields the following:

DATE	SAMPLE RESULTS			
	alpha d/m/ml	beta d/m/ml	U ug/l	NO_3 mg/l
January 29, 1982	0.016	0.046	8.1	52
April 30, 1982	----	----	----	45
June 25, 1982	0.013	0.030	8.6	----
August 27, 1982	0.013	0.031	7.5	38.4
November 19, 1982	0.014	0.083	9.6	68
January 21, 1983	0.014	0.018	9.1	49.7
April 29, 1983	0.014	0.069	12.1	25.3
August 31, 1983 [1]	----	----	----	18.0
September 30, 1983 [1]	0.010	0.048	13.2	----
October 28, 1983	0.015	0.058	11.1	21.7
January 27, 1984 [2]	----	----	----	----
April 30, 1984	0.017	0.051	7.8	7.4
August 28, 1984 [2]	----	----	----	----
November 27, 1984	0.017	0.025	9.0	<0.5
January 25, 1985	0.020	0.020	8.6	<0.5
April 19, 1985	0.020	0.025	9.9	1.5
August 27, 1985	0.0157	0.0172	12.0	<0.5
January 3, 1986 [3]	----	----	12.0	----
February 19, 1986	0.0239	0.0302	10.0	0.5
March 14, 1986 [3]	----	----	10.0	----
April 18, 1986 [3]	----	----	10.0	----
May 21, 1986 [3]	----	----	11.0	----
June 17, 1986	0.0232	0.0179	12.0	<0.5

NOTES:

1. Results for alpha, beta and U not attainable because the sample was prematurely acidified. Another sample for alpha, beta and U was obtained on 9/30/83.
2. No sample obtained for T1S because the pump motor was not working.
3. In 1986, WMCO initiated monthly sampling for U. Other parameters continue quarterly.

Mr. Arthur's Quality Control Audit Report No. 4.02, dated January 31, 1985, includes the following finding:

> "35. Step 6.2.43 states, 'Inspect pump and equipment at No. 1 shallow test well.' This step should be deleted from the SOP, as the operation at No. 1 Test Well is no longer performed."

The procedure step cited required utilities personnel to check the pump motor several times a day and add oil, if necessary.

The audit report finding was assumed to relate to the fact that, since continuous pumping at T1S has ceased roughly six months prior to his audit, step 6.2.43 of the procedure was out of date and needed to be deleted.

A review of on-site documentation and interviews with a number of WMCO operations personnel indicated that the T1S pump was in place at the time of the audit. However, the motor had been out of service for several months immediately preceeding the audit (Only the motor for the pump is visible above ground).

A review and inspection of the current status of T1S operations indicate everything is in order. As of January, 1986, samples for uranium are being collected monthly.

CONCLUSION:

Although continuous pumping at T1S was terminated in June, 1984, and the frequency of sample collection in 1983 and 1984 was nominally less than the quarterly intervals used in earlier years; there is no evidence there was any intent to phase out or discontinue environmental monitoring activities at this location. Data in the public record, principally the Environmental Monitoring Reports for 1984 and 1985, substantiate this.

Relative to the statement that "uranium levels were too high," information in the record shows no observable transient in the uranium levels observed and reported over the last few years at T1S. A comparison of uranium levels in the T1S samples to those at the plant's combined discharge to the Great Miami River in 1985 indicate the T1S water contained far less uranium than the routine plant discharges.

ISSUE NO. 15: EXPOSURE LIMITS IN THORIUM STORAGE AREAS

o RESIGNATION LETTER, PAGE 1

> "Although, the Fernald Site is a Thorium Depot for DOE, no procedure exists that includes information on the maximum allowable time an individual should be in the thorium storage areas."

FINDINGS

Thorium-232 is stored in a wide variety of chemical forms at the FMPC. It is currently stored in seven locations: Building 64, Building 65 (and a pad west of Building 65), Building 67, Building 68, a storage silo near Plant 8, a storage bin on the roof of Plant 8, and Storage Tank #2 west of the Pilot Plant. Until the late 70's, thorium was also stored in Building 71. Work in the storage buildings has historically required the issuance of a Radiation Work Permit (RWP) according to WMCO staffers; however, only two buildings (67 and 68) were locked to prevent access by plant personnel. These buildings were locked in the mid-70's. Buildings 64 and 65 were subsequently locked following extensive radiation surveys in the summer of 1985.

High Radiation Areas (greater than 100 mrem/h) exist in only a few areas of the thorium storage buildings; however, Radiation Areas (greater than 5 mrem/h) extend beyond the confines of the buildings. These areas were not roped-off or posted until July, 1985. Dose rates in the range of 20 to 30 mrem/h are common in areas surrounding the storage buildings. Until 1985, there was no boundary or posting to limit personnel access to these areas. Radiation area boundaries were also established at the Plant 8 thorium storage silo and bin, and at Tank #2 in the summer of 1986. Ambient radiation levels at these sites are lower than those in the vicinity of the storage buildings and typically range from 2 to 4 mrem/h. Boundaries were originally established at 4 mrem/h. These boundaries were recently (as of 10/86) extended to incorporate all areas with ambient dose rates exceeding 2.5 mrem/h.

In addition to providing better access controls to the thorium storage areas, the WMCO health physics staff has prepared a draft procedure requiring the issuance of an RWP prior to performing work in these areas. Although the issuance of RWP's for entry to the thorium storage buildings has been past practice, historical documentation of this practice is lacking. There is no assurance that RWP's were, in each instance, issued prior to personnel entering the buildings. Combined with the fact that the buildings were not posted or locked until the dates discussed above and the fact that thorium was stored at the FMPC since the 1950's, there is a strong basis for Mr. Arthur's concern. At the time of Mr. Arthur's March, 1986 resignation, the investigation team believes that access controls to the major thorium storage areas had been established although written procedures had not yet been completed.

CONCLUSION

Mr. Arthur's concern has been verified in that written procedures for access control did not exist during his period of employment at the FMPC. A procedure now exists (as of 10/13/86), although it has not yet been issued. "Stay times" will be specified through RWP's to limit worker exposure in the thorium storage areas.

ISSUE NO. 16: LAUNDRY PROCEDURES FOR CONTAMINATED CLOTHING

o RESIGNATION LETTER; PAGE 2

> "No procedures exist for the laundering of process clothing at the Fernald Site."

FINDINGS

Today, the laundry operates essentially the same as it did during Mr. Arthur's employment with the FMPC. Each production worker normally wears two pairs of coveralls per shift, and coveralls are washed each time they are worn. Written procedures for laundry pickup and delivery and for operating washing machines and dryers do not exist. Procedures for laundry operations should be written to ensure proper handling and control of contaminated clothing.

Currently, laundry workers randomly monitor ten percent of all laundered coveralls for contamination. Those found to be contaminated above the WMCO limit for process clothing are rewashed and resurveyed. If clothing cannot be satisfactorily decontaminated, it is disposed of. Prior to the implementation of this new monitoring requirement, health physics technicians spot checked laundry for contamination on a monthly or quarterly basis. Due to the increased clothing contamination surveillance and the recent addition of a new washing machine at the laundry, there has been a noticable decrease in process clothing contamination levels.

CONCLUSION

Written procedures for laundry operations do not exist. Current laundering practices are adequate; however, written operating procedures should be developed.

RECOMMENDATION

WMCO should develop procedures for laundry operations.

ISSUE NO. 17: ALARM SYSTEMS COMPLIANCE WITH OSHA 1910.165, NFC 72F, AND ANSI 2.4

o RESIGNATION LETTER; PAGE 2

> "Fernald Site currently uses an Emergency Message System in conjunction with the Plant Emergency Alarm System. The Emergency Message System is not in compliance with OSHA 1910.165, "Employee Alarm Systems," or NFC 72F, "Standard for the Installation, Maintenance, and Use of Emergency Voice/Alarm Communication Systems."

o RESIGNATION LETTER 2; PAGE 2

> "The Individual Building Evacuation Alarm Systems currently used at the Fernald Site are not in compliance with OSHA 1910.165, or NFC 72F. Also, no Individual Evacuation Alarm System exists for the Laboratory Building, however, parts for the system have been on site since early October 1985."

o RESIGNATION LETTER; PAGE 3

> "The Radiation Detective Alarm Systems currently used at the Fernald Site are not in compliance with ANSI 2.4, 1979, ANS, "Immediate Evacuation Signal For Use In Industrial Installation."

FINDINGS

On February 7, 1986, WMCO management established an ad hoc committee to review all personnel safety alarm systems at the FMPC. Mr. Arthur was a member of this six person committee. The committee findings were reported in a letter from the Committee Chairman to the Vice President of Environmental, Safety and Health on February 28, 1986. To quote directly from this letter:

> "The (emergency message) system does not presently meet any of the applicable OSHA or NFC requirements."

> "Requirements for ... (individual building evacuation alarm) systems are found in NFC 72F 'Standard for the Installation, Maintenance and Use of Emergency Voice/Alarm Communication Systems' and OSHA 1910.165 'Employee Alarm Systems'... The present building evacuation alarm systems do not meet these requirements."

> "Equipment for the (building evacuation alarm) system to be installed in the Laboratory Building has been on site since early October, 1985, however, installation has received a low priority by Engineering."

> "ANSI standard 2.3, 1979, ANS 'Immediate Evacuation Signal For Use In Industrial Installations' governs the design and installation of alarms associated with the radiation detection devices in use at FMPC. Much like the standard that applies to the Plant Emergency Alarm System a secondary power supply is required, however, supervision of conductors is not a requirement and neither has been provided on this system. Alarm devices are required to have a sound level which is not less than 10 dba

> above background. Alarm horns supplied with the new RDA devices fail to meet this criteria."

Mr. Arthur's statements are factual; however, the alarm system review was initiated by WMCO management in order to identify problems requiring corrective action. Management acknowledged concerns over the FMPC alarm systems prior to Mr. Arthur's involvement on the review committee.

A project to upgrade the emergency message system is currently underway. One hundred six thousand dollars have been allocated for this project. When completed, the system will be in compliance with applicable OSHA and NFC requirements. Project completion is tentatively scheduled for February, 1987.

The ES&H line item project includes a subproject to upgrade building evacuation alarm systems. The subproject will begin in 1987.

The Laboratory Building evacuation alarm system has been installed. Installation was completed on October 13, 1986.

All horns on radiation detection alarms (RDA's) are currently being replaced by air-driven horns. The use of air-driven horns will alleviate the need for a secondary power supply and electrical supervision of the alarm circuits. These new horns sound well-above 10 dba.

CONCLUSIONS

Personnel safety alarm system deficiencies identified by a WMCO ad hoc committee on February 28, 1986 are a matter of record. WMCO has taken proper action to correct these deficiencies.

ISSUE NO. 18: GAS ODOR IN LABORATORY BUILDING BASEMENT

o RESIGNATION LETTER; PAGE 3

> "A strong gas odor was detected in the Laboratory Building, Basement South Tunnel, during a routine safety inspection on Friday, February 15, 1985. The gas leak was immediately repaired, but individuals have continued to smell gas in the same tunnel, over the past few months."

FINDINGS

NLO'S February 22, 1985, Safety, Housekeeping and Maintenance Inspection Report for the Technical Division, from C. E. Polson to R. M. Spenceley stated the following:

> "The safety, housekeeping, and maintenence inspection of the Technical Division areas was performed on February 15 and 19, 1985, by Daniel J. Arthur of Quality Control Department."

The report further stated, "The laboratories, offices, and corridors were generally neat and clean with the exception of the general utility area of the basement, where a general cleanup is needed."

A note at the end of this same report stated the following:

> "Note: A gas odor was detected in the South Tunnel of the Laboratory, and was promptly reported to maintenance personnel in the area. They corrected the problem."

Review team members examined similar Safety, Housekeeping and Maintenance Inspection reports for the Technical Division through December, 1985. No other gas odor detections were observed or reported during that period.

Representatives from the review team accompanied Nelson Weichold, of WMCO's Quality Control System Development, on a tour of the Laboratory building's basement, including the north, east and south tunnel areas. Mr. Weichold informed the team members that he had been with Mr. Arthur on his February 15, 1985 inspection tour of the south tunnel and that they both had detected a natural gas odor.

Mr. Weichold showed the team members the location where they had discovered the gas leak and informed the team that maintenance personnel were notified immediately of the problem. No natural gas odor was noticed in the south tunnel during the team's inspection tour.

CONCLUSION

The inspection tour of the south tunnel, interviews of laboratory personnel and a review of Safety, Housekeeping and Maintenance Inspection Reports for the Technical Division, yielded no evidence of any continued problems with natural gas odors in the south tunnel.

ISSUE NO. 19: ADEQUACY OF PROCEDURES FOR HOISTS AND CRANES

o AFFIDAVIT; PAGE 5

> "In my audit of hoists and cranes used at Fernald, where, after finding widespread discrepancies in compliance with procedures in Plant 5, I was restricted from performing other hoists and cranes audits throughout the facility."

o RESIGNATION LETTER; PAGE 1

> "Several hoists and cranes in use throughout the Fernald Site are not included in a Preventive Maintenance Program."

FINDINGS

Two Quality Control (QC) audits were conducted in 1983 on hoists and cranes in Plant 6 and Plant 9.

Mr. Arthur conducted a Quality Control audit on hoists and cranes in Plant 5 in August, 1984. The Plant 5 QC audit was issued on November 16, 1984. A follow-up audit was conducted and issued October 24, 1985. This follow-up identified several items remaining to be resolved. Response to the follow-up stated all unresolved items identified in the follow-up audit would be completed by December 31, 1985.

A field check was performed on October 23, 1986 to assure items identified in the 1985 follow-up audit had been completed. The field check showed that while some of the items had been corrected, other items remained unchanged. All equipment checked was in the Preventive Maintenance System.

Discussions with maintenance personnel did reveal that several new cranes/hoists had not been put into the Preventive Maintenance System before they were put into service. Maintenance had not been informed to do so. These items are now in the PM System.

Discussions could not confirm if NLO/WMCO field checks had been performed to confirm the status of all cranes/hoists in the PM System.

CONCLUSION

There still exists discrepancies between the capacity marked on hoists and cranes and the capacity marked on the supporting members. Three cranes/hoists were not labeled with identification numbers. The weight capacity on one crane/hoist was not readily visible. The standard operating procedure has been changed to require inspection prior to use to prevent overloading of cranes, slings and lifting devices. The possibility of cranes/hoists not being in the PM System still exists.

RECOMMENDATION

Checks should be made to assure that cranes/hoists are in the PM System, and that they are properly labeled with capacity signs visible to the operators.

Senator METZENBAUM. Did you want to respond further, sir?

Mr. BERUBE. With respect to emissions of air pollutants, I do not have specific numbers in terms of reductions, but I would like to indicate some of the physical improvements that have been made.

Air pollution control system—upgrades have been made. In-stack samplers, breakthrough monitors, and HEPA filters have been installed. Physical control equipment and administrative controls have resulted in significant reductions of emissions.

Two additional off-site, ambient air monitors have been installed. An on-site meteorological tower has been installed and operating since September 1986. An expanded radon monitoring network is being installed, as well as other equipment and improvements.

With respect to groundwater contamination, the principal sources of groundwater contamination at Fernald related to old waste areas, as well as surface runoff into Paddy Run, which then enters into the groundwater system. With respect to surface runoff, the Fernald facility has completed a retention basin which would hold the surface runoff and treat it if necessary before releasing it to Paddy Run.

With respect to the groundwater contamination related to the old hazardous waste pits, there is an extensive program of installing groundwater monitoring wells to fully characterize the nature and the extent of the groundwater contamination.

And that all is being done as part of the Federal facilities compliance agreement that we have with EPA. A site-wide remedial investigation and feasibility study is also being conducted.

Senator METZENBAUM. Currently, in spite of all the work that you claim is being done, on June 30 a press conference was held at the Fernald plant by the Health and Environmental Advisory Committee. That is the Health and Environmental Advisory Committee at Fernald made up of Fernald area residents and scientific experts. They expressed concerns about the inadequate alarm system, the lack of protection given to Fernald employees during a mock disaster drill on April 25, and the handling if six barrels containing nuclear waste destined for a Nevada test site.

What actions, if any, have been taken by DOE to address these concerns because that is a very recent meeting?

Ms. WALKER. I would like to say, Senator, in response to that is I would like to offer to investigate that. I was not aware that that meeting had taken place. I do know that our Operations Manager, Joe LaGrone, is very positive on having the public involved. I think this advisory committee was his initiative. And if they raise concerns, it is the process set in place to address those concerns. But I would like to personally look into this inasmuch as you have raised it. And I was not aware of it as having taken place.

Senator METZENBAUM. Madam Secretary, we are happy to work with you, but frankly I think there has been a feeling in the Fernald area that there has been more talk and less action than that which is necessary. I will bring about the meeting between you and the Attorney General from the State of Ohio to see whether or not between us we can't implement a little faster program of action because I think your heart is in the right place, but I am not sure that the follow-through action is sufficient. We'll be back in touch.

Ms. WALKER. Okay.

Senator **METZENBAUM**. I look forward to hearing the answers to some of the questions that were left unanswered.

Ms. **WALKER**. Thank you.

The **CHAIRMAN**. Thank you, Madam Secretary.

Ms. **WALKER**. Are you finished with us, sir?

The **CHAIRMAN**. We are finished at this time.

Ms. **WALKER**. Thank you.

The **CHAIRMAN**. Thank you very much. Next, we have the Environmental Protection Agency with Dr. J. Winston Porter, Assistant Administrator for Solid Waste and Emergency Response Office, accompanied by Ms. Lisa Friedman, Associate General Counsel; by Gene Lucero, Director of the Office of Waste Programs Enforcement; and by Chris Grundler, Director of Federal Facilities Compliance Task Force.

Dr. Porter, you may begin and if you can summarize your statement, we will certainly appreciate it.

STATEMENT OF DR. J. WINSTON PORTER, ASSISTANT ADMINISTRATOR, SOLID WASTE AND EMERGENCY RESPONSE, ENVIRONMENTAL PROTECTION AGENCY, ACCOMPANIED BY LISA FRIEDMAN, ASSOCIATE GENERAL COUNSEL; GENE LUCERO, DIRECTOR, OFFICE OF WASTE PROGRAMS ENFORCEMENT; AND CHRIS GRUNDLER, DIRECTOR, FEDERAL FACILITIES COMPLIANCE TASK FORCE

Dr. **PORTER**. Thank you, Senator. I want to just take a second here and introduce the people with me, and then we will go into EPA's testimony. I will try to keep it fairly brief.

I have with me Lisa Friedman from our Office of General Counsel on my right. To my extreme left, Chris Grundler, who is head of a new Federal Facilities Task Force we have established, and Gene Lucero who is head of our Office of Waste Programs Enforcement to my immediate left.

What I would like to do today is discuss, as was indicated in the letter of request, DOE compliance with Superfund and RCRA. I am going to discuss briefly the general application of RCRA and Superfund to the DOE. Then I want to mention a few specific tools and examples that we can talk to you about today.

First off, the Resource Conservation and Recovery Act, or RCRA, we feel does apply to Federal facilities. We have made that point for a long time. And I think we have made real progress in this area. Examples it includes the permitting of various kinds of disposal facilities, assuring that there is ongoing compliance with RCRA, and implementing the so-called corrective action provisions of RCRA where you have to clean up units which have experienced problems from past practices.

Likewise, Superfund applies to Federal facilities, including those at DOE. And what we are generally using there as the tool is the interagency agreement called for under section 120 of Superfund.

One issue we have had to deal with, Senator, at a lot of the DOE sites and at other sites as well is that there is often both RCRA and Superfund work required at a given location. And so, we have had to develop a strategy in which we can address both RCRA and Superfund at a particular site.

Our general strategy is to develop enforceable arrangements at all these facilities, with involvement by both citizens and the states. We are starting with the 13 major DOE facilities which are mentioned in my written testimony.

Let me just mention a few specific enforcement tools we have, and then I want to talk about a couple of examples.

There has been a lot of dialogue the last few months among ourselves at EPA, the Department of Justice, the Department of Energy, Department of Defense and others on what exactly are the appropriate tools to use in both RCRA and Superfund.

In an April 18 hearing this year before Chairman Dingell's committee, the Energy and Commerce Oversight Subcommittee, the Department of Justice clarified a number of issues, and I just want to repeat those briefly because I think they are very important. I want to reiterate those, as well as give your interpretation.

The tools we have to require Federal facilities compliance are several. One is the negotiating compliance agreements under RCRA, section 3008(a), agreements which are then enforceable by citizens and states. We can also issue corrective action orders—that is, cleanup orders—to Federal facilities under RCRA as part of the permitting process. This is made clear by DOJ and, in fact, we are using that authority.

Number 3, we can take direct action on both compliance and corrective action issues under RCRA against the contractors at government-owned, contractor-operated facilities. This is a very valuable tool, a very powerful tool whereby if we do not get cooperation from the Federal facility in question and there is a contractor who can be construed to be the operator of that site, we can then use those tools directly against the contractor.

Finally, under Superfund, as I mentioned, we can develop interagency agreements and, in fact, can use so-called 106 enforcement orders against Federal facilities, which are then, in fact, enforceable by citizens and states.

Senator, let me close by mentioning a couple of examples of recent success stories regarding DOE facilities, and then we would be happy to take your questions.

One of these is the Rocky Flats nuclear plant in Colorado where last summer we got what we think was a very good enforceable compliance agreement to cover both RCRA and Superfund. This agreement had several good provisions, including schedules which are enforceable. And in fact, the State of Colorado was quite pleased with that agreement, and it looks like it is working to date.

Another one we have just finished, which is a little different kind of an agreement, is the Idaho National Engineering Lab. In this case we have a so-called consent order and compliance agreement which addresses both corrective action and compliance issues. Again, this agreement has good enforceability language and includes a new dispute resolution clause which makes the EPA Administrator the final decision maker or disputes such as those regarding selection of remedy.

So, those are some of the things we have done and some examples of successes. We are placing a very high priority on Federal facilities. It has been a very tough issue to come to grips with, but I am reasonably confident now that we are on a good track. What we are going to try to do with DOE is work through those 13 facilities, or about half of these we already have some kind of arrangement which we may need to strengthen in some cases.

As I have mentioned, we have also set up a new task force under Chris Grundler to my far left to really pull together a lot of our capability to deal with Federal facilities.

So, that is where we are, and we would be happy to take your questions.

[The prepared statement of Dr. Porter follows:]

STATEMENT OF
J. WINSTON PORTER
ASSISTANT ADMINISTRATOR FOR
SOLID WASTE AND EMERGENCY RESPONSE
U.S. ENVIRONMENTAL PROTECTION AGENCY
BEFORE THE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
OF THE
COMMITTEE ON ENERGY AND NATURAL RESOURCES
U.S. SENATE

July 17, 1987

Mr. Chairman and Members of the Subcommittee, I am J. Winston Porter, Assistant Administrator for the Office of Solid Waste and Emergency Response. I am responsible for implementation of the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or "Superfund" at the Environmental Protection Agency (EPA). I appreciate this opportunity to discuss our efforts to implement these programs at Federal facilities. With me today are Lisa Friedman, Associate General Counsel; Gene Lucero, Director, Office of Waste Programs Enforcement; and Chris Grundler, Director of the Federal Facilities Compliance Task Force.

Through enactment of RCRA and CERCLA, Congress empowered EPA to manage hazardous wastes and to remedy the environmental problems caused by improper past management of these wastes and other hazardous substances. To achieve these goals in a uniform manner throughout the country, it is clear that Congress intended that its mandate for action in waste management include those facilities owned and operated by the Federal government.

Public concern has arisen, however, regarding the compliance of these Federal facilities with RCRA regulations and the adequacy of overall efforts to clean up uncontrolled site problems and respond to releases at existing and former Federal facilities under RCRA or CERCLA.

Some time ago, EPA Administrator Lee M. Thomas established the goal that waste management and cleanup at Federal facilities serve as a model for the similar activities that we require of the private sector. Our goal is to ensure that the Federal Government demonstrate leadership in environmental control practices through Federal facility compliance with air, water, toxic chemical and hazardous waste requirements.

Today, I would like to discuss our authorities to assure Federal facility compliance and cleanup and our current course of action. I have also included an appendix to my testimony which summarizes the current status of compliance at selected DOE facilities that may be of interest to members of the Subcommittee.

I. RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

The hazardous waste management objectives and provisions of RCRA are applicable to Federal facilities. By the express statutory language of RCRA section 6001, Federal facilities are subject to the provisions of RCRA and its implementing requirements. Moreover, Executive Order 12088 assigns responsibilities to administrators of executive agencies for (1) the prevention, control and abatement of pollution, and (2) assurance that funds sufficient to attain "compliance with standards" are requested.

There are currently 29 DOE treatment, storage and disposal facilities identified as hazardous waste facilities. Of these 29 facilities, EPA plans first to focus attention on the 13 major DOE facilities that may pose environmental concern. They include (but are not listed in order of priority):

- Feed Materials Production Center (Fernald), Ohio
- Savannah River Plant, South Carolina
- Hanford Reservation, Washington
- Rocky Flats Plant, Colorado
- Idaho National Engineering Laboratory (INEL), Idaho
- Los Alamos National Laboratory, New Mexico
- Lawrence Livermore National Laboratory, California
- Nevada Test Site, Nevada
- Oak Ridge National Laboratory, Tennessee
- K-25 Site, Tennessee
- Y-12 Plant, Tennessee
- Sandia National Laboratories, New Mexico
- Portsmouth Uranium Enrichment Plant, Ohio

We have made considerable progress at INEL and Rocky Flats, and we are working with DOE to develop equally effective arrangements at other sites.

A. RCRA Permitting Requirements and Corrective Action

All active Federal treatment, storage and disposal (TSD) facilities handling hazardous waste must have RCRA permits. In addition, Federal TSDs must address any releases of hazardous waste to the environment. Specifically, Section 3004(u) of RCRA requires corrective action of releases of hazardous waste and constituents from both active and inactive solid waste management units (SWMUs) at facilities that have or are seeking a permit.

Moreover, Section 3004(v) authorizes EPA to require corrective action beyond the facility boundary. In addition, Section 3008(h) of RCRA authorizes EPA to issue consent orders requiring interim status facilities to take corrective action or other necessary response measures whenever it is determined, on the basis of any information, that there is or has been a release of hazardous wastes or constitutents from a facility.

B. Inspections and Compliance

There are 322 Federal facilities engaged in the management of RCRA Subtitle C wastes. These represent about 6.4% of the total universe of TSD facilities. Under RCRA 3007(c) and (d), EPA (or authorized states) must conduct an annual inspection at all Federal facilities. EPA has implemented this HSWA provision. Additionally, the Agency's RCRA Implementation Plan requires that all land disposal facilities (including Federal LDFs) receive a comprehensive (groundwater) monitoring evaluation (CME) to determine compliance of each facility's groundwater monitoring system once every three years. In FY-86 for example, we inspected all 74 Federal land disposal facilities (LDF)s and all 246 Federal treatment/storage facilities. In addition, 49 or 67% of the Federal LDFs received a comprehensive groundwater monitoring evaluation.

Where inspections of Federal facilities by EPA and the states have disclosed violations we have taken steps to obtain compliance. Serious violators of groundwater monitoring or closure/post-closure requirements are known as "significant noncompliers" (SNCs) and the status of enforcement activity to address their violations is tracked and reevaluated quarterly.

At the beginning of FY-86, 35 of the 74 Federal LDFs (47%) were SNCs. At the end of FY-86, 100% of these Federal SNCs had either returned to compliance voluntarily or had been addressed by an action such as an order or consent agreement and were in compliance with that order or agreement. At the beginning of FY-87, there were 36 Federal SNCs (which included FY-86 beginning-of-year Federal SNCs that had not returned to compliance). Preliminary results of the Agency's Strategic Planning Management System (SPMS) 3rd quarter (June 30, 1987) data indicate that 26 (72%) of the 36 beginning-of-year Federal SNCs have either returned to compliance or have had an action taken against them.

In addition to inspecting to determine if there are any violations under RCRA, EPA conducts RCRA facility assessments to determine if there are any releases of hazardous waste to the environment. To date 22 (30%) of the 74 Federal LDFs have had a RCRA facility assessment (RFA). So far the results of these RFAs indicate that 20 (91%) of the 22 Federal LDFs appear to have releases. Our information indicates that at least 6 (or 30%) of the Federal facilities which appear to have releases have begun the corrective action process to address these releases.

II. COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA)

The Superfund Amendments and Reauthorization Act of 1986 (SARA) makes it clear that Superfund applies to Federal agencies, both procedurally and substantively. The specific requirements for Federal agencies are found in section 120 entitled "Federal Facilities." Section 120 sets forth a process to ensure that Federal agencies assess and cleanup their hazardous waste sites within specified time frames. This process is under EPA's oversight and provides States and citizens the opportunity to be involved.

A major activity under SARA is establishment of the Federal Facility Hazardous Waste Compliance Docket. Two efforts are underway: 1) development of the initial list of facilities on the docket at the time of enactment; and 2) establishing the repositories of the documents required by the specified statutes.

Another effort is to develop the Property Transfer Regulations as required by Section 120(h). In cooperation with the General Services Administration we have set up a schedule for promulgation of a regulation to meet the 18 month deadline.

We have been developing interagency agreements (IAGs) at several Federal facilities. The objective of the IAG is to establish frameworks and schedules for remedial and corrective actions to be taken by Federal facilities under CERCLA, and where feasible and appropriate we hope to use the IAG to resolve outstanding issues under other statutes, including RCRA and State law.

One difficult issue is to determine whether the contamination problems at Federal facilities are covered under CERCLA or RCRA, or both. Our position is that where the cleanup could be compelled under either RCRA or CERCLA, the choice of law to effect cleanup is contingent on a number of factors. Our overall objective is to ensure that cleanups under RCRA and CERCLA are as consistent as possible and are conducted as expeditiously as possible.

III. ENFORCEMENT PROCESS FOR FEDERAL FACILITIES

It has been a difficult task to develop a workable enforcement strategy for Federal facilities. Since the beginning of both the RCRA and CERCLA programs in the early years of this decade, the Agency sought to apply these laws to Federal facilities in the same manner as they are applied to any other person.

However, there are differences between the private sector and government entities which bear upon the enforcement process to be used. First, funding for Federal facilities, including that for pollution control, is requested by the President and appropriated and overseen by Congress. Second, many Federal facilities have national security functions which, because of this paramount interest of the United States, may have to be balanced against environmental priorities. The President may grant an exemption for these purposes under most environmental statutes, including RCRA and CERCLA. Third, EPA cannot litigate enforcement actions against other parts of the executive branch. These differences bear upon the enforcement process to be used.

It is also clear that Federal agencies which cannot resort to courts to settle disputes within the executive branch are also concerned about having a process for dispute resolution before the matter is subject to third party litigation. EPA has been working diligently to define this process. When necessary, judicial enforcement action would be available pursuant to citizen suit authority and state enforcement authority.

Over the past several months, there has been considerable discussion over the means EPA has to compel Federal facilities to comply with requirements of environmental laws and regulations. In particular, EPA, the Department of Justice (DOJ) and the Department of Energy (DOE) have been discussing whether EPA has the authority to issue orders to Federal facilities under RCRA. At a recent Congressional hearing before the House Energy and Commerce

Oversight Subcommittee on April 18, 1987, DOJ identified a constitutional impediment to the use of unilateral orders, but clarified that EPA's authorities under RCRA §3008(h), §3013 and CERCLA §106 can be use to respond at federal facilities. DOJ, DOE and EPA are now in agreement that orders can be issued to federal agencies under these provisions.

In light of DOJ's clarification on EPA's authority to issue administrative orders at Federal facilities, EPA fully intends to use the full range of enforcement authorities available to ensure Federal facility compliance.

A. Resource Conservation and Recovery Act (RCRA)

There are three important actions which EPA can take as a result of DOJ's clarifications in the April 28, 1987 hearing. These relate to compliance issues under 3008(a) of RCRA and corrective actions under 3008(h) of RCRA. Discussed below are EPA's interpretations of these items and the process by which they will be applied to federal agencies and government owned contractor operated facilities (GOCOs).

1. Federal Facility Compliance Agreement

DOJ stated that EPA cannot issue 3008(a) unilateral orders to other Federal facilities. Therefore, in the case where a Federal facility is not in compliance with RCRA, a Federal Facility Compliance Agreement (FFCA) will be negotiated. A very important section in any new FFCA is the enforceability clause. We are urging that the enforceability clause be added to existing Federal Facility Compliance Agreements. This language reflects DOJ's view that the term "requirement" in RCRA §7002 includes statutory and regulatory requirements and other items that are mandated by these requirements (e.g., schedules of compliance, various plans, recordkeeping and reporting) and that the requirements imposed by the final negotiated document are enforceable under RCRA Section 7002.

2. Corrective Action Orders (3008(h)) at Federal Facilities

With regard to corrective action and the issuance of Administrative orders under §3008(h) of RCRA, DOJ has taken the view that all corrective actions are integral to the permitting process. Since §6001 of RCRA makes specific reference to permits, DOJ has concluded that administrative orders under §3008(h) can be issued to Federal facilities. Whenever violations exist at a facility, EPA will enter into a "Consent Order." Based on this DOJ determination, order authority under §3008(h) will be exercised whenever possible and appropriate on consent.

In some cases there will be both corrective action and compliance issues at Federal facilities. In this case EPA will exercise a "Consent Order and Compliance Agreement" with the Federal facility.

For example, EPA Region 10 in Seattle, Washington recently entered into a Consent Order and Compliance Agreement with DOE's Idaho National Engineering Laboratory (INEL). The document is the first such order issued to a DOE facility and addresses issues where the INEL facility is not in compliance with RCRA and needs to initiate corrective action. It outlines corrective actions needed where waste facilities are releasing contaminants to the environment. The document recognizes the rights of third parties, including states, to enforce its provisions. Actions and schedules to achieve and maintain compliance with requirements for addressing the release and/or potential release of hazardous wastes, and substances and other constituents from the facility are included. We plan for this document to serve as a model for similar conditions at other DOE facilities.

3. Issuance of Orders to a Government Owned Contractor Operated Facility (GOCO)

Enforcement actions using §3008(a) and 3008(h) of RCRA against GOCOs can be a valuable enforcement tool, especially at facilities where the contractor does the majority of the waste management work. This is typically the case at DOE facilities.

DOJ has determined that EPA has the option of taking an enforcement action against the non-Federal operator of a facility. This authority is not limited to RCRA compliance issues under 3008(a). It includes corrective action authority under 3008(h).

GOCOs should not be shielded from enforcement actions for non-compliance with environmental laws. Therefore, I have urged the EPA Regional offices to carefully consider the operator of any facility when determining what enforcement tools to exercise. When the contractor at a Federal facility is clearly the operator, RCRA authorities available for non-federal facility actions (i.e., Section 3008(a), 3008(h), and 3013 orders) will be considered.

B. CERCLA

1. Section 120 Interagency Agreements

Under Section 120 of the Superfund Amendments and Reauthorization Act of 1986 (SARA), Federal agencies must enter into an "interagency" agreement" (IAG) for all necessary remedial actions at a Federal facility. In many cases, facilities subject to an IAG will also have RCRA liabilities.

The most common example of the RCRA/CERCLA overlap is where a facility is undergoing a CERCLA remedial investigation and is seeking a RCRA permit. Before the RCRA permit is issued, the facility must comply with the corrective action requirements of 40 CFR Part 264, Subpart F, as required by Sections and 3004(u) and (v) of RCRA. Corrective action under 3008(h) or a postclosure permit will also be required for all facilities seeking to close a hazardous or solid waste management unit at a RCRA facility.

The Agency is pursuing the idea of using Section 120 IAGs to solve this "choice of law" question at certain Federal facilities. Section 120 IAGs would incorporate both RCRA and CERCLA activities under one enforceable agreement and would be a comprehensive plan for investigatory and remedial activities at the facility, whether RCRA or CERCLA. The agreement would satisfy the facility's corrective action requirements, subject to public participation at the time of permit issuance. The permit would then incorporate the IAG's requirements as permit conditions.

The DOJ has indicated that EPA also has authority to issue section 106 administrative orders to Federal facilities. If the Region has difficulty negotiating an agreement for CERCLA response actions at a Federal facility an available enforcement option is a CERCLA Section 106 administrative order. Headquarters is working on general procedures, under the Executive Order 12580 consultation process to follow for referring CERCLA Section 106 orders to DOJ.

IV. CLOSING REMARKS

In conclusion, I think the difficulties we have experienced in the past in our attempts to make Federal facilities models of compliance are being overcome. I am hopeful that DOE, other Federal agencies and EPA will work through compliance and corrective action issues using available RCRA and/or CERCLA authorities.

I want to assure the Committee that Federal facility compliance and corrective action problems are going to get the attention they need. For example, I have formed a Federal Facilities Task Force in the Office of Waste Programs Enforcement. Task Force staff will be able to devote the time necessary to assure that all parties involved in the complex process of obtaining funding, resolving problems, and, where necessary, issuing orders, will be drawn together so that decisions can be made. They will help develop policies and procedures to assure quick and consistent action by States and EPA Regions.

I thank you for your attention. I look forward to your views on these issues and would be happy to answer any questions you may have.

APPENDIX
TO
STATEMENT OF
J. WINSTON PORTER
ASSISTANT ADMINISTRATOR FOR
SOLID WASTE AND EMERGENCY RESPONSE
U.S. ENVIRONMENTAL PROTECTION AGENCY
BEFORE THE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
OF THE
COMMITTEE ON ENERGY AND NATURAL RESOURCES
U.S. SENATE

July 17, 1987

The current status of several selected DOE facilities are attached, summarizing progress that has been made toward addressing RCRA and CERCLA violations.

Idaho National Engineering Laboratory (INEL)

DOE's Idaho National Engineering Laboratory (INEL), near Idaho Falls, reprocesses and recovers spent nuclear fuel from several test reactors, the nuclear naval fleet and other nuclear noncommercial reactors. The facility is known to have numerous RCRA violations including: an inadequate groundwater monitoring program, failure to apply for interim status for certain units and inadequate closure/post closure plans. Releases of hazardous waste and/or hazardous waste consitutents into the groundwater have occurred.

EPA and DOE have negotiated a Memorandum of Agreement (MOA) which contains a workplan outlining procedures and schedules for assessing health and environmental threats at all known solid waste management units (SWMUs) and land disposal units on the 570,000 acre INEL facility. The workplan has four major requirements: (1) installation of a groundwater monitoring network, (2) compliance with closure/post-closure requirements, (3) a RCRA Facility Investigation (RFI) to determine the nature of extent of contamination, and (4) necessary corrective action.

The above MOA has been executed by DOE and the Geological Survey, but not EPA. DOE is implementing the technical portion of the MOA.

Most recently EPA and DOE signed a Consent Order and Compliance Agreement under RCRA for the cleanup of hazardous waste and compliance at INEL. The Consent Order and Compliance Agreement addresses RCRA compliance issues at the INEL Facility. In addition, it outlines corrective actions needed where waste facilities are releasing contaminants to the environment and provides for state and citizen lawsuits to enforce the provisions, if necessary. Actions and schedules to achieve and maintain compliance with requirements for addressing the release and/or potential release of hazardous wastes from the facility are included. Steps that DOE will take to address compliance with regulations governing past land disposal of hazardous waste and constituents are also addressed in the document.

Hanford Facility

The DOE Hanford facility in Richland, Washington produces plutonium for nuclear weapons and advanced reactor development. The facility has a number of RCRA violations including inadequate ground water monitoring, inadequate closure/post closure plans, and storage of hazardous waste in excess of 30 days. The facility also has releases of hazardous waste and hazardous constituents which have been detected in ground water and soil.

The State of Washington and EPA issued a complaint in February of 1986, which addressed all of the RCRA violations noted above, but did not address corrective action needed at the facility. In October, 1986 the state issued a consent order. EPA was not a party to the order. The facility is believed to be on schedule with the order and is installing ground water monitoring wells at four units as a result of the State consent order. The facility is planning some process changes to reduce the volume of hazardous waste/constituents generated but much more of this work is needed.

Since the State of Washington is authorized to manage the RCRA program (excluding HSWA), EPA's strategy for achieving compliance with RCRA at Hanford is to work closely with the state to assure that the environmental and health risks of regulated units are fully mitigated. Although the existing Consent Order does not address a number of additional land disposal units recently identified (20 in all), Hanford is negotiating with the State concerning compliance issues at these units.

EPA's authority includes solid waste management unit (SWMU) investigations and corrective actions (as well as other HSWA authorities). Our strategy for achieving compliance with these requirements is to develop achievable schedules for carrying out investigations, characterizing problems, and developing remedies. These (schedules or remedies) would be incorporated into the Part B permit at the time of issuance. We have received Hanford's listing of all waste management units including SWMUs (1200 SWMUs); however, we have not yet started negotiations on specific work outputs for prioritizing and conducting remedial actions at the SWMUs. EPA is currently developing a strategy for the implementation of investigatory and remedial actions at the site.

Fernald Facility

The DOE Feeds Materials Production Center in Fernald, Ohio processes uranium for use in weapons. The facility has a number of RCRA violations, including: an inadequate groundwater monitoring program, failure to submit Part B to obtain interim status for certain units, inadequate sampling and analysis plan, incomplete waste analyses of generated waste, and incomplete closure plan/post closure plan. The facility is also known to have releases of uranium that are appearing in some local wells. Certain uranium compounds have also been released to the local air and soil.

In July 1986, a multimedia Federal Facility Compliance Agreement (FFCA) became effective. It addresses, among other media violations, all RCRA violations previously identified. This FFCA requires compliance or actions intended to achieve RCRA compliance in the fall. As of today, two violations are still uncorrected: a determination of whether each waste maintained on-site (approximately 35,000 drums) is hazardous and implementation of an adequate groundwater monitoring program. DOE is moving forward to correct these violations.

Additionally, the FFCA addresses CERCLA issues. Specifically, DOE must complete a Remedial Investigation/Feasibility Study (RI/FS) at the Fernald facility and implement the EPA approved remedial actions. Pursuant to federal facilities compliance agreements and negotiations with EPA, DOE submitted its work plan on January 30, 1987, and EPA is continuing to review this work plan for adequacy.

The Ohio Attorney General's Office sent DOE a Notification of Intent to File Suit. On March 11, 1986, the Ohio Attorney General filed a complaint regarding violations of Ohio hazardous waste regulations. This action is currently in the discovery process.

Mound Facility

The DOE Mound Facility in Mound, Ohio conducts explosives and nuclear technology research. The facility failed to obtain interim status for certain units and had an inadequate contingency plan, but subsequent inspections (1986 and 1987) showed the facility to be in compliance with all applicable RCRA regulations.

A State of Ohio law suit refers to a 1969 spill of plutonium-238 which may have contaminated soils, surface water, and groundwater. The extent of releases is being addressed through a study to be conducted under DOE's CERCLA program. A preliminary assessment was also completed in March 1986, by the Ohio EPA (OEPA). DOE is responsible for conducting the site investigation prior to CERCLA scoring.

OEPA visited the site numerous times during the summer of 1985 to monitor the facility's progress toward achieving compliance. DOE is currently conducting an investigation to determine if the facility has impacted the environment. To date, no RCRA enforcement actions have been initiated.

Portsmouth Uranium Enrichment Plant

The DOE Portsmouth Uranium Enrichment Plant in Portsmouth, Ohio produces enriched uranium fuel for use in production reactors and commercial reactors. Inspections showed the facility has a number of RCRA violations including: an inadequate groundwater monitoring program, inadequate freeboard on surface impoundments and incomplete waste analysis for waste placed on their treatment facility. Preliminary investigations have detected the presence of several hazardous wastes or hazardous waste constitutents in the groundwater on-site. These include trichloroethylene, 1,1-dichloroethane, and Freon 113.

In September 1986, a Federal Facility Compliance Agreement (FFCA) became effective. It addresses all RCRA violations that have not been corrected. This FFCA requires compliance with all applicable RCRA regulations by December 30, 1986. As of today DOE has completed many requirements of the FFCA and is moving toward complete compliance with RCRA. The remaining work to be completed includes conducting a hazardous waste determination, installing additional RCRA groundwater monitoring wells, and implementing the groundwater quality assessment program.

Currently, EPA is drafting a Corrective Action Consent Order (3008(h)) which requires a RCRA Facility Investigation/Corrective Measures Study (RFI/CMS) at the facility. Upon completion, the Corrective Measures will be implemented. The actions taken will be selected by EPA.

On March 18, 1987, the Ohio Attorney General's Office issued a Notice of Intent to File Suit to DOE for past noncompliance at the Portsmouth Plant.

Savannah River Plant

DOE's Savannah River Plant (SRP) is located in Aiken, South Carolina. The 300 square-mile facility produces nuclear materials, primarily plutonium and tritium, for defense purposes. The facility has numerous RCRA violations including: an inadequate groundwater monitoring program, failure to apply for interim status for certain units and inadequate closure/post-closure plans. Releases of hazardous constituents, particularly trichloroethane, have occurred in at least one waste management area at SRP. Other releases are suspected but monitoring well systems must be upgraded to document the releases. The source of the releases are believed to be from a seepage basin at the fuel manufacturing area which is no longer in use at the facility.

South Carolina has final authorization for HSWA and EPA is working closely with the State on the facility. Currently DOE has signed four settlement agreements with the State (7/85, 11/85, 6/86, 10/86); all for alleged different RCRA violations. A fifth settlement agreement with the State for an inadequate Part B submission is expected shortly and a sixth settlement agreement covering all outstanding alleged RCRA violations will follow. SRP is in compliance with all schedules in existing State agreements. A Federal Facility Compliance Agreement addressing operation without interim status has been drafted by Region IV. The agreement is currently under negotiation.

EPA and the State are in the process of developing RCRA land disposal permits for the facility. These permits, when approved, will contain schedules that address corrective action at solid waste management units.

The Chairman. Thank you very much, Dr. Porter.

Do you believe that the condition of DOE facilities from an environmental standpoint is worse than other Federal facilities?

Dr. Porter. Well, Senator, I certainly think they have some of the worst problems. I do not know if I would make that broad a statement, but I think that there are cases where they have got very, very serious environmental problems.

The Chairman. Are they making progress in addressing these environmental issues?

Dr. Porter. I think they are. I think we are trying to speed up that progress. But I think one of the problems has been getting these enforcement tools in place, and now that we pretty much have those in place, I think we can move much faster.

The Chairman. Thank you.

Senator Evans?

Senator Evans. Let me just ask one question that is beyond EPA's current responsibility, but perhaps you have enough information to give me some of your advice.

How would you characterize the Defense Department's actions in the handling of their waste problems from the N-reactor at Hanford?

Dr. Porter. Well, that is not directly under my jurisdiction.

Senator Evans. I know it isn't.

Dr. Porter. But I will give you a comment.

Senator Evans. Yes.

Dr. Porter. I think there have been some issues there, as I understand it, with respect to water discharges. EPA is developing a new permit for water discharges that will be used, if and when that reactor reopens. I think that we can come to grips with that situation. I think that the water issues, from what I have heard, are solvable problems, and we will have to address these.

Senator Evans. How about the handling of the high-level nuclear waste, however?

Dr. Porter. I really have a hard time commenting on that, Senator. I am just not involved with that.

Senator Evans. It's too far outside your——

Dr. Porter. I might make one perhaps somewhat peripheral comment though, and that is that we now have authority to handle under RCRA so-called mixed waste where you have a chemical component and a radioactive component.

Senator Evans. I understand.

Dr. Porter. And that may be helpful in some cases.

Senator Evans. Maybe what we have to do is throw a little of that mixed waste in there so that suddenly you have got that under your purview. [Laughter.]

Dr. Porter. That may be one approach.

Senator Evans. It is not a bad idea. Somebody to go out with a little canister of some—you know, tell us what is mildly bad but bad enough so you can get involved, and we will throw it in there.

Dr. Porter. We will take that under advisement.

Senator Evans. Do you have any comment on the handling again by the Defense Department of some of the hazardous but non-nuclear wastes on the Hanford reservation? Some stories have come out just recently on some of the problems of those and especially some of the transfer problems in the soils. Have you had a chance to investigate that problem?

Dr. PORTER. We are in the process of doing it. I will say that we certainly are concerned about the direct disposal, in effect, into the ground of some of the mixed wastes and the cribs and so forth. We are in the process now of examining our new mixed waste authority. We think many of those discharges perhaps do have a chemical component, as well as a radioactive component. That would allow us to get involved from two or three standpoints as far as RCRA is concerned.

What I think in general we have got to do with the groundwater problems at Hanford is, frankly, a fair amount of quick analysis, as well as prioritization. There are lots and lots of disposal sites at Hanford. What I am concerned about, Senator, is that we attack the worst problems first—if something is going on right now that is not a good idea, try to get our arms around that. And, in addition to any need for immediate source controls, we need to look at past practices and decide which problems are more important than others. We think there are something like 1,000 solid waste management units at Hanford. We clearly cannot attack all of it at once. We need to decide which problems are the most important and prioritize them.

Senator EVANS. Again, even though you do not have the high-level nuclear waste under your purview, would you suggest that of the various waste management programs at Hanford that that potentially ought to have the highest priority?

Dr. PORTER. Well, as you say, it is not directly under my jurisdiction, but I think the high-level program in general can include some very dangerous issues. These may be life-threatening issues, and we certainly have got to give a high priority to those.

Senator EVANS. Thank you, Mr. Chairman.

The CHAIRMAN. Senator Wirth?

Senator WIRTH. Thank you very much, Mr. Chairman.

Dr. Porter, I appreciate your being here. I read your statement earlier, and from that I take it that EPA feels that it has reached an acceptable compromise with Justice and DOE over the enforcement of administrative orders under RCRA and Superfund?

Dr. PORTER. I think that is a fair statement, Senator. We still have some degree of concern in some of the compliance areas, the so-called 3008(a) areas, but I think generally we feel like we have got a lot of tools to work with now.

Senator WIRTH. I was previously in the House of Representatives and was very involved with the writing of the 1986 Superfund amendments. And I remember that we gave EPA a very significant, as I remember it, set of responsibilities in deciding what remedial action ought to be taken at Federal facilities. That was a very important set of discussions. And we all understood in doing that that there had to be a lot of cooperation between agencies, but somebody ultimately had to be responsible.

Is it your understanding that you do have that responsibility, that even while you coordinate with everybody that the final decision has to be made by you, and is that the way the amendments are being interpreted?

Dr. **PORTER**. Yes, it is, Senator Wirth. As a matter of fact, in this Idaho National Engineering Lab agreement, which we signed last week, it is fairly specific that in the event of a dispute that the EPA Administrator will make the final decision.

Senator **WIRTH**. And as I remember it as well, one of the things we were concerned about was what would you do if a Federal facility, like in my backyard, Rocky Flats, which I know you are torturously familiar with—if Rocky Flats or some other facility was leaking or was not cleaning up toxic wastes that you were then in a position to order them to do so. Is that right?

Dr. **PORTER**. That is correct, yes, sir.

Senator **WIRTH**. Now, tell me what limitation or what inhibition will come about or will there be any with the entry of an administrative order. Will that in any way inhibit you or will that in any way inhibit the states or in any way inhibit citizens' groups?

Dr. **PORTER**. Well, I think there are several things I might say, Senator. And some of the other folks here may want to comment on that too.

We are trying to craft an arrangement where we can make some progress before the lawsuits enjoin. For example, one issue we discussed and are discussing in some cases now is that we would like to to be able to get farther into the study process and avoid suits occuring during the process of developing the alternatives in a plan. Once we get into that process where we know what is wanted, we are trying to craft agreements in such a way that citizens and states can enforce them.

We are also trying to craft these things such that the schedules are enforceable. One of the concerns we have had is that neither a Federal facility nor anyone else should delay indefinitely in terms of doing studies and so forth. So, we are trying to craft arrangements where there is an enforceable schedule so that people can go into court if in fact the Federal facility or others are not meeting the schedule.

And so, there are clearly a number of issues we are trying to work on right now——

Senator **WIRTH**. I understand that. Let me go back.

The administrative order is entered. If the State of Colorado or the State of Washington wants to come in and sue, and argue that you are not complying with the statute, or if the Sierra Club or the state health department wants to come in and sue, can they still do that?

Dr. **PORTER**. Yes. We have put for example, in the Rocky Flats agreement pretty explicit language that the provisions of that agreement are, in fact, enforceable by citizens and states. We have defined that the state is a person under the aegis of RCRA and so forth.

Senator **WIRTH**. And there is no limitation on their ability to sue, is that right, under the administrative order? Mr. Lucero?

Mr. **LUCERO**. Senator, I might add a couple of points that need to be clarified.

It depends to some extent under which authority one is proceeding. If you are proceeding under the RCRA authorities and you are using either corrective action order authority under section 3008(h) or you are using permit authorities, citizens have a very clear right to intervene if they can meet the test of the citizenship provision at any time. There are some provisions for giving notice and so forth.

In the case of CERCLA, Superfund, there are different arrangements. First of all, we could issue orders under section 106, or under the new statute established by SARA, we may enter into interagency agreements under section 120 of SARA (Superfund Amendments and Reauthorization Act of 1986). Both of those orders are enforceable by citizens.

However, we read them as being subject to the limitations on pre-enforcement review that the Congress established in section 113. And what that means is the ability of a citizen to actually intervene and challenge, for example, certain questions around the design of the remedial investigation or feasibility study, which might be a subject of one of those two orders, will be constrained by the statute itself. But the citizens still have a right to——

Senator WIRTH. Not by the administrative order.

Mr. LUCERO. That is right.

Senator WIRTH. As long as it is in the statute, they can go ahead, and they have not been inhibited in any way.

Mr. LUCERO. Not by the order.

Senator WIRTH. Let me ask you a final question, if I might, Dr. Porter.

Could you tell us what has been the relationship of the Department of Justice to what the Congress asked you to do? Have they in any way over the last year inhibited your ability to go out and be the lead agency in cleaning these up or in stopping Federal facilities from further contamination of the environment?

Dr. PORTER. No, I do not think so, Senator. I think there has certainly been some legal debate on various points from time to time. I think the statement that Mr. Henry Habicht made before the Dingell subcommittee recently clarified a lot of these points. And there was a lot of legal dialogue on what the law said and so forth, but I think generally we have found them to be fairly cooperative. I will not say there has been no acrimony and no debate between us and them and other people because it has taken some time to work through what these issues really mean.

Senator WIRTH. Can you now bring suit? Can EPA? Are you completely free to bring suit if a Federal facility is not cleaning up as it ought to, or if a Federal facility is leaking, can you bring suit?

Dr. PORTER. No.

Senator WIRTH. You cannot do that.

Dr. PORTER. No. As a general matter, I think what the Department of Justice said is one Federal agency should not be suing another Federal agency.

Senator WIRTH. Well, but what was your interpretation before the Department of Justice intervened as to what the intent of the Congress was?

Dr. PORTER. Well, I think that we have to rely on them as the government's lawyers to decide——

Senator WIRTH. What was the interpretation of EPA before the Department of Justice got into it? I mean, hasn't this been an issue of some significant concern as to what—Mr. Chairman, my understanding was that the Department—that the Congress had given EPA some very significant authority in the Superfund amendments of 1986 and that we were expecting that you were going to be not only the lead agency but were to intervene and, if necessary, as a last resort were going to be able to move in and sue that particular facility.

Mr. LUCERO. Senator, if I could add to what Dr. Porter said. There is not a precise provision in the law that authorizes or directs—that is, in SARA—that directs EPA to litigate against other Federal agencies. There are statements elsewhere that one could argue suggest that.

But it has been an issue of longstanding within the administration as to whether or not EPA can use its general litigation authority to sue a Federal agency. And much before Dr. Porter's time that debate started and, in fact, has been discussed with the Department of Justice.

The Department of Justice has essentially advised us and advised the Congress I think in at least two separate letters to House committee chairmen saying that in their view that there is a constitutional prohibition against the EPA bringing a lawsuit against another Federal agency. And on the basis of that particular reading, we have not brought litigation.

However, when we draft these agreements, there are other means for enforcement of them, the administrative orders. For example, citizens can enforce them. States who are often parties to these consent agreements, whether they are consent orders or otherwise, can also enforce them either as citizens or in some cases because they are the responsible authority, and it has been entered into under their authority as well.

And it is a disparity between the way we might deal with private parties and Federal facilities, but it is as Justice has established it.

Senator WIRTH. So, where we sit right now is that the states can come in and sue. No problem. Citizens' groups can come in following what is in the statue. Citizens' groups can. It had been my understanding that we gave that authority to EPA in the statute in 1986. Justice has come and said, no, it is unconstitutional for EPA to do that, sue another Federal agency. Others believe that EPA has independence on this issue. And that was my understanding of the intent of the 1986 amendments. The Justice Department is saying, no, you cannot do that.

Is that a fair summary of where we are, Dr. Porter?

Dr. PORTER. Yes, I think that is right. I might say though, Senator, there is one thing we have done. I mean, we have not been silent on this issue. We have worked very hard, for example, to authorize states to handle mixed wastes to try to increase their authority in this arena as much as we can and to try to work very hard in these agreements so that the citizens or states can, in fact, litigate these issues.

Senator WIRTH. Mr. Chairman, I appreciate your having this hearing, and thank you very much.

The CHAIRMAN. Thank you, Senator Wirth.

Thank you very much, Dr. Porter, and gentlemen and ladies.

Dr. PORTER. Thank you very much.

The CHAIRMAN. Next we are very pleased to have members of the independent panel who reviewed the N-reactor facilities, with Dr. Louis Roddis, Jr., Consultant; and Dr. Gerald F. Tape, also Consultant. We are very pleased to have these two distinguished experts with us. Dr. Roddis, welcome. Dr. Tape, welcome. We are pleased to have you here before us.

Dr. RODDIS. I am Lou Roddis. Do you want me to start, sir?

The CHAIRMAN. Yes, please.

STATEMENT OF DR. LOUIS H. RODDIS, JR., CONSULTING ENGINEER, CHARLESTON, SC

Dr. RODDIS. I have a prepared presentation. However, in the interest of time I would brief it if you would introduce the whole thing.

The CHAIRMAN. Yes. The written statements will be put into the record.

Dr. RODDIS. Thank you, sir.

I am an engineer of some 48 years' experience, 41 in the nuclear field. I was chairman of a panel of six independent consultants who were requested by the Secretary of Energy to report to him on the implications of the Chernobyl accident on the Hanford N-reactor.

The principal focus of my recommendations made October 3 to the Secretary is that the N-reactor should be replaced as soon as possible. In the short term it should be shut down until a number of changes are accomplished, the principal one in my estimation being the inerting of zone 1 of the containment.

I will not quote the details of the report. I would also appreciate the entire report being made a part of the record. I find it has been quoted and misquoted from a number of times. For the record, I would like to say that Secretary Walker has always quoted me quite accurately.

Parenthetically, in amplification of one of the paragraphs of the recommendations on continued operation, I would like to emphasize that I am referring to the plutonium producing mode of operation of the reactor which is the mode it has been operating in. If it is operated as a major tritium production facility, more review of the reactor physics needs to be done than was available to our panel of consultants in mid-1986, the point being that with a higher enrichment required——

The CHAIRMAN. Would you pull the microphone just a little closer, Dr. Roddis?

Dr. RODDIS [continuing]. The point being with a higher enrichment required, there are some different physics problems.

I would also like to touch on three more general points which I have mentioned a couple of times. They were in my report but were not made as recommendations.

First is the effect of the Federal budget process on safety. In all licensed reactors, including Federal, state and municipally owned ones, the utility must spend whatever funds are required by the NRC to effect plant safety and take their chances of recovering those expenditures sometime in the future if ever. The DOE, however, has to get funds in advance from Congress, OMB and their own internal processes with no special emphasis on nuclear safety.

I have no specific recommendations. The Federal budget process is certainly sufficiently complex already without any of my ideas.

But it is a fact that money and safety have a bearing on each other.

Secondly, the responsibility for the safety review process is somewhat diffused in the Department, and this leads to my recommendation that the position of Assistant Secretary for Environment, Safety and Health be established as a statutory, required position in the Department of Energy. Secretary Herrington should receive great credit for having established the position in its present level, but another secretary could greatly change the emphasis on that function.

Thirdly, there has been much mention by many of the need for a credible, permanent outside review process of some kind, which leads to my second recommendation that the Advisory Committee on Reactor Safety be utilized by the Department of Energy to perform an overview of the Department's nuclear safety reviews in the same manner it does for the NRC licensed reactors. This should include the required public reports on the construction and operation of those reactors. If it is not practical to do this, then a similar review body should be established and staffed to provide such an overview for the Department of Energy facilities.

Thank you, sir.

[The prepared statement of Dr. Roddis follows:]

Oral presentation.
to the
Sub-Committee on Energy Research and Development.
of the
Senate Committee on Energy and Natural Resources.
by
Louis H. Roddis, Jr., P.E., C.Eng.,
Consulting Engineer.
Charleston, S.C.
July 17, 1987.

My name is Louis H. Roddis, Jr. I am an engineer of 48 years experience, 41 of that in the nuclear area. A brief biography is appended.

I was the Chairman of a panel of six independent consultants who were requested by the Secretary of Energy to report to him on the implications of the Russian Chernobyl unit 4 accident on the operations of the Hanford "N" dual purpose production reactor. This is the only U.S. power reactor even remotely resembling the Chernobyl units in design.

The principal focus of my recommendations made October 3, 1986 to the Secretary of Energy is that the "N" reactor should be replaced as soon as possible. In the short term it should be shut down until a number of changes are accomplished, the principle one in my estimation being the inerting of the Zone one of the confinement.

The summary of this report is quoted below. I respectfully request that the entire report and appendices be included in the record.

"SUMMARY:

1. The Advisory Committee on Reactor Safeguards in 1966 identified the basic hazards of the "N" reactor as follows:

> " The Committee again points out that radiological consequences in the unlikely event of a severe reactor accident at the N-Reactor during 4000 MW(t) operation would exceed the dose guidelines now used for licensed power reactors."

I believe this situation is unchanged today.

Therefore I recommend that the Department shut down the "N" reactor unless a positive judgement is made that the requirements for defense material warrants accepting public hazards exceeding those of commercial reactors.

2. If continued operation for the next several years is considered to warrant acceptance of these hazards, then a short term Action plan should be provided and executed based on the various sources of recommendations identified in the "Recommendations" section below. Briefly these include the 88 recommendations of the Departmental review teams that have just reported to you and some additional steps, especially those aimed at reducing the potential for a hydrogen explosion.

With these changes operation at the present power levels and core loadings can continue until 1990-1991 without risks increasing much over those now existing.

3. If continued production of Defense materials is required long term, replace the "N" reactor by a less unique design, with provision for accident mitigation similar to commercial reactors. This will be a challenging task, but is not a new idea. It was studied extensively in the 1982 time frame, but never executed, apparently for economy reasons."

Parenthetically, in amplification of paragraph 2 above from the body of the text,I would like to emphasize that I am referring to the plutonium producing mode of operation of the reactor, which is the mode it has been operating in. If it is operated as a major tritium production facility more review of the reactor physics needs to be done than was available to our panel of consultants in mid 1986. I also suggested that all of a number of suggested recommendations be accomplished by October 1, 1987, the date then scheduled for a new contractor being responsible for the operation of the "N" reactor.

Since the announcement and public release of our consulting opinions in December 1986 my only knowledge of what is being done at the Hanford "N" reactor has come from sources available to the public.

Besides answering any questions on my report to the Secretary I would like to discuss the following three more general items that are touched on in my report. They are in the nature of governmental matters that were not specifically asked for by the Secretary, and hence were not shown as recomendations in my report, although they were discussed therein.

First the effect of Federal budget processes on safety. In a licensed reactor (including Federal, State and Municipal owned ones) the utility must spend whatever funds are required by the NRC to effect plant safety, and take their chances of recovering these expenditures sometime in the future, if ever. The DOE however has to get funds in advance from the Congress, OMB, and their own internal processes, with no special emphasis on nuclear safety. I have no specific recommendations, the Federal Budget process is sufficiently complex already without any ideas from me.

Secondly the responsibility for the safety review process is somewhat diffused in that the contractor, the field office, the program HQ office, and the HQ ESH are all involved to some extent in the safety responsibility process. While ESH does have shutdown authority it is in case of overriding need only, in other words ESH has to positively show something is unsafe, rather than the opposite. Also the position of Assistant Secretary for ESH exists, I believe, at the pleasure of the Secretary. Secretary Herrington should receive great credit for establishing the position at it's present level, but another Secretary could greatly change the emphasis on this function.

1.This leads to my recommendation that the position of Assistant Secretary for Environment, Safety and Health be established as a statutory required position in the Department of Energy.

Thirdly there is a need for a credible permenant outside review of the DOE activities in the nuclear safety area. Both the independent consultants group review of "N" reactor and the NAS review committee is ad hoc in nature, and while I believe them to be credible in themselves, there is no question in my mind but that a permenant overview body should be established. I do not think it appropriate for the NRC to be involved directly, but perhaps the ACRS could be utilized, either in it's present form as an NRC appointed independent body, or better yet as one appointed by the President, which has an overview function for both the NRC and DOE. Until the division of the Atomic Energy Commission the ACRS functioned in this way. I believe it can still do so at the request of the Secretary, but this has only been done on rare occasions, and there is the problem of staffing and funding for such work, since the ACRS is now appointed and supported by the NRC.

2.This leads to my second recommendation, that the Advisory Committee on Reactor Safety be utilized by the Department of Energy to perform an overview of the Departments nuclear safety reviews in the same manner it does for the NRC licensed reactors. This should include required public reports on the construction and operation of those reactors. If it is not practicable to do this, then a similar review body should be established and staffed to provide such an overview for the Department of Energy facilities.

Louis H. Roddis, Jr.

Consulting Engineer.

The CHAIRMAN. Why don't we hear from Dr. Tape first before we go into questions?

STATEMENT OF DR. GERALD F. TAPE, CONSULTANT, WASHINGTON, DC

Dr. TAPE. Thank you, Mr. Chairman.

I am going to skip around a little bit, and I will consolidate much of my statement so we will shorten the time.

The various recommendations that I included in my report to the Secretary I have enumerated again and made some comments on the present status. I would like to pick out a few of those just to elaborate.

My first one had to do with the question of whether or not the reactor would be so upgraded that there might be a production enhancement program and its operation might continue into the next century. I was pleased when the decision was made, and I must say with the help of Congress, to settle that particular question. So, there is a definite situation that we are not talking about moving into the next century. We will let it go to its natural life expectancy.

The second one had to do with getting together the contractor, the various people in DOE, and so on in coming up with an action plan for the safety enhancement program. That was done in December. And a number of the specific recommendations that I asked that there be questions looked into and so on are included in that plan. And I think that plan constituting what is going on right now is a good plan and, in fact, from what I have understood—I have not followed it in any detail at all, but from what I understand, I think it is going forward.

I might add parenthetically that although the under secretary took the action in accordance with Assistant Secretary Walker's statement of shutting down for a sufficiently lengthy time that you could get a lot of these done, I understand now that that shutdown period will be extended for various reasons. And I myself feel that that is in the right direction for many reasons. One, I would like to see as much of that program be done before start-up can proceed.

Finally, in the recommendations I had also one that touched on the one that Mr. Roddis just brought up having to do with budgets, financing and so on of the improvement programs and future improvements. And I support that.

I also brought up the question of greater use of external peer review which I would like to come back to in a few minutes.

I might say that I was pleased also that the new contractor—let me say first I was disturbed that there would be a contractor shift at this crucial period of time, but I am pleased that the new contractor, Westinghouse Corporation, is involved in an extensive review of its own. And I think that is a very good position to take because it will have the responsibility when start-up continues, and it is satisfied with the safety conditions at that time.

In addition to the specific recommendations, I had some observations that I made to the Department. One of these has to do with what I call public perception and the acceptance of risk. And through my years having been trained as a scientist, I was more interested in facts generally, and I always thought the public would come around to recognize the facts. But as you people here know very well, that is not always the case. In fact, the public perception as recognized by the polls today tends to govern more of what this country does than sometimes the facts would warrant. So, there is this pressure to create an external advisory mechanism beyond what exists now. And I for one have some concerns with what I believe to be the mechanisms under consideration either by some of the members of the Senate, Congress, and also by the Department.

Let me say that from a safety point of view, I like to put the pressure on and insist on good operations. I want to see prevention. And in that context I would like to see the emphasis also be on the operating side and not layer upon layer upon layer of oversight, regulation and so on. We ought to be able to get it done in one bite.

I think also whatever mechanism is developed that it should be——

The CHAIRMAN. When you say in one bite, you mean?

Dr. TAPE. If you were on the operating side today, and are subjected to, as you heard for the N-reactors, three reviews from the Department of Energy, Mary Walker's shop, six of us, the Academy committee and all of the others who have come it, the operators have a great problem of just keeping things under control while they are being looked at by all these multitudinous groups that come in.

I am simply saying that I think we ought to somehow be able to bring that to a focus where we do not have an undue burden of oversight compared to getting the operations side in good shape.

The CHAIRMAN. We are presently studying the question of how to get that oversight. And I would very much like your advice either now or after you have a chance to think about it.

Dr. TAPE. Well, my plea here is that whatever we do, let's try to do the simplest thing. And I might expand. I have not looked at it in detail, but I do have some thoughts along the following line.

I am a little uneasy about another independent agency which I seem to read into some of these proposals for this independent board. Every agency of the government that establishes itself creates its own career, its own lifetime and so on. And that just makes me nervous. I think one of the problems in the country today is too much bureaucracy in trying to do what we are hoping to achieve. It is an overhead situation.

Why is it so necessary? It tends to be necessary because each level does not trust the level beneath it. I hope somehow we could improve that trust.

Let me expand a little bit. The NRC has ACRS, the Advisory Committee on Reactor Safety. It is in the legislation. It is statutory in that sense. And it advises the NRC. Is there a way of visualizing something like that for DOE short of an independent agency? To be sure, there are differences because NRC is looking at the private sector in general where the owner is not the government. It is not DOE. So, there is this differentiation where the government, DOE in this case, is both owner-operator and regulator. But I believe it is possible to have an ACRS-type, if I may call it that, independent type of arrangement which could be responsible to the Secretary and achieve much of what is being talked about.

I throw this out, Mr. Chairman, because as I say, I have an uneasy feeling about creating additional independent agencies to achieve factors of this kind. So, in your consideration, could we be a bit open-minded to try to get as smooth a working operation as possible recognizing the need for independence, to be sure.

And that gets back to part of my public perception too because in the mind of the public, the independent body is more trustworthy, if I can use that word, than the government body.

If I may go on, one other observation I had for the Secretary was on DOE organization and practice. And here I look at reactor safety in this case as a very, very important matter. And if there are matters that come to the attention—and I do not care whether it is on the operations side of the house or on the regulatory side of the house, it is important that those questions get to headquarters in a very rapid time. I think any of those major questions has got to have a headquarters decision. It is not one you leave to the contractor. You do not leave it to the field. It does involve all parties.

The parties in general who are the ones who really can make the decisions—the contractors have to be in because they have the real operational expertise of that particular facility. The field office manager needs to be in because it is the sort of delegated arm of DOE to interact with the contractor. But headquarters itself is involved frequently. A decision like shutdown, a decision requiring more money to do a certain improvement and so on are things that cannot be handled remotely.

And my plea here in effect is to somehow see to it that the decision making line and process is as short as possible. I have seen it work in the past where instead of asking each level to come up with its recommendation and each person who has to sign on to that recommendation spends hours agonizing over what he or she will say before signing, I have found from past experience getting the three parties in the room at the same time on deciding on what should be done is a faster way of handling these safety problems.

The reverse is true also on implementation. And so, it is a plea for trying to simplify the present system of long lines of communication, long periods of decision making. I find today even if you put the recommendation in the mail, you are lucky to get it next week. And this is not the way to handle safety problems. So, I did have a plea in there. Can we not somehow look at that on the operations side?

One final comment, Mr. Chairman. In implementing the system that is there today of creating the environment, safety and health division, it was necessary to pull a lot of expertise into that group, and they have done a good job of that. At the same time I think there is a deficiency on the operations side of DOE at the headquarters and field level. There are not an infinite number of people, experts in this field. And so it is important to try to pull things together I think and have the expertise on the operations side as well.

I have been troubled by the following, and this is more than defense production reactors. There are 11 class A reactors which the National Academy of Sciences and Engineering are looking at on behalf of the Department. Those 11 are distributed geographically around the country. In one way or another the contractors responsible report to five different operations office managers. Each operations office manager has to have his expertise in operations, regulations and so on. Those five operations offices, with respect to their particular responsibilities, report to three different program offices. And short of the Under Secretary himself, there is no place where this sort of comes together as a reactor safety impetus on the operations side. And I think there is some merit in thinking about internal organizations which can give greater emphasis on the operations side because there is where the ultimate safety resides in the people who have to run those reactors and see to it that they are operated safely.

Those are my comments, Mr. Chairman.

[The prepared statement of Dr. Tape follows:]

N-REACTOR SAFETY

A Presentation by

Gerald F. Tape

to the

Subcommittee on Energy Research and Development
Senate Committee on Energy and Natural Resources

July 17, 1987

I am Gerald F. Tape, one of six consultants asked by the Secretary of Energy to review N-Reactor safety in the light of the Chernobyl accident. I am retired but, from time to time, consult and serve on advisory committees. Former positions I have held include those of Deputy Director Brookhaven National Laboratory, President Associated Universities, Inc. (contractor and operator of the Brookhaven National Laboratory for the Department of Energy and the National Radio Astronomy Observatory for the National Science Foundation), Commissioner U. S. Atomic Energy Commission, and U. S. Representative to the International Atomic Energy Agency. I have served on numerous government advisory committees including the President's Science Advisory Committee and the Defense Science Board.

My report, "N-Reactor Safety in the Light of the Chernobyl Accident," was transmitted to Secretary Herrington on October 1, 1986. In brief, I concluded that the initiating event leading to the accident at Chernobyl could not happen at N-Reactor; however, there were lessons to be learned. As we all know, the Chernobyl accident stimulated much examination of all reactors and, because of some similarities with the Chernobyl RBMK, examination of the N-Reactor was DOE's highest priority. Three different DOE teams appointed by the Assistant Secretary for Environment, Safety and Health (ESH) reviewed N-Reactor safety during the summer of 1986. Based on recommendations of the review teams and by the consultants, a safety enhancement program (SEP) was developed. In December 1986, Under Secretary Salgado directed that the planned reactor refueling outage scheduled for January 1987 be extended for up to six months in order to accelerate the implementation of the recommended safety measures. I strongly supported that decision; many of the recommendations could then be expeditiously implemented. The contractor, by being relieved of immediate production requirements, could give the program number one priority. I understand that start-up will be delayed beyond the six months date. There is merit in continuing the SEP momentum and priority at this time.

A few general remarks are in order before referring to the specific recommendations in my report. Chernobyl and Three Mile Island demonstrated that, for the severe accidents that did happen, the initiating event was unanticipated, that is, it was not previously treated as credible. If one assumes that some kind of an unanticipated major accident could occur at N-Reactor, the seriousness of the consequences would most likely be governed by the presence of steam and hydrogen and the ability to control high pressures and/or to prevent explosions in the confinement space. The burden to respond would be on the control room staff and the back-up emergency response team. Factors such as professional training and education, quality assurance and surveillance are very important. In addition, complacency arising from years of successful operation and long periods of repetitive routine operations, so common to many high-technology operations, must be overcome.

A number of recommendations were made for the Secretary's consideration. They are repeated here with additional information or comments relevant to developments since October 1986.

I. DOE should decide now that the safety enhancement program for the N-Reactor will be directed toward its continued operation for the next five to ten years and that its operational life will not be extended beyond its "natural life."

With the help of Congress, this decision has been made. The "production enhancement program" has been terminated, and the present program for the N-Reactor is based on an assumption that operations will not extend beyond 1995. Heroic measures for reactor life extension are not in the plans.

II. In conjunction with the contractor, prioritize the numerous recommendations with respect to implementation and, on an urgent basis, establish and fund plans consistent with N-Reactor operations for the short term.

The directed extended shutdown has allowed a safety enhancement program to proceed on an accelerated schedule with recognized priority.

III. A. Re-evaluate the generation and control of hydrogen under accident conditions. Investigate the methods of prevention of build-up of explosive mixtures and detonation, for example, controlled burning, recombiners, inerting.

B. Expedite and expand the PRA analysis. The contractor should be intimately involved, but the magnitude of the task and the urgency require responsibility to be assigned to one organization with the authority to draw on the resources of other groups on an expedited basis. Some questions cannot wait for the PRA results and should be addressed in the interim on a best-estimate basis.

These analyses and investigations are well underway. It is my understanding that the NAS/NAE Review will specifically address hydrogen generation and mitigation.

IV. A. Analyze and test each component and sub-system of the confinement system to the maximum extent feasible to ensure its proper operation.

B. Re-evaluate the expected chemical forms and quantities of iodine release and the effectiveness of the spray and filter systems in their removal.

These activities are well underway. It is my understanding that certain aspects of the confinement test program will extend beyond what I had perceived to be possible, that is, to more closely approach a partial system test.

V. A. Emphasis must continue on the training function including conforming manuals and simulator performance to actual control conditions.

B. Continue to strengthen through education the on-site control room capability to respond to unusual and unanticipated events.

C. Maintain a vigorous surveillance and replacement program, especially with regard to process tube failure and graphite growth.

These recommendations refer to activities undertaken during the shutdown period and continuing for future operations. Major attention is being given to examination of process tube integrity during the present shutdown. This will not only eliminate suspect tubes now but will provide a better data base for ongoing surveillance.

VI. DOE must facilitate design, funding and construction of identified support equipment where changes are recommended in the interest of reducing the vulnerability.

Capability for remote shutdown and remote monitoring is being established. FY 1987 funding for SEP is being accomplished to a considerable measure by reprogramming. Adequacy of out-year funding remains to be determined.

VII. DOE should make greater use of external peer review groups to address reactor safety on a continuing basis. The use of external entities such as ACRS and INPO should be pursued.

Secretary Herrington has endorsed the concept of an institutionalized external review mechanism. The specific arrangements remain to be determined.

In my report to the Secretary, I offered a few general observations related to DOE safety management and decision making. The two topics I wish to discuss here are public perception and risk and DOE organization and practice.

Public perception and risk

Public perception, whether factually correct or not, is important. Public opinion polls reflect public perception. It is difficult for a public official to act in a manner counter to the public's perception. For example, "licensing" of a nuclear reactor by a body independent of the plant owner-operator is perceived as a more safety-credible process. While DOE has taken steps in this direction by establishing ESH, DOE remains both the owner-operator and the regulator of the N-Reactor. The pressure is on to establish an external advisory mechanism. In my opinion, such a mechanism is necessary, and it should be only advisory. In the case of the defense production reactors, the balancing of risks, that is, operating with some, though minimal, safety risk versus that of insufficient weapons material, must remain with the government. There is no other source of special nuclear material for defense purposes other than from the DOE defense production reactors. In the case of power reactors, a utility normally has the option of buying replacement energy, at an increased cost, as long as there is available excess reserve capacity in the region. For the aging defense production reactors, the issue becomes one of balancing cost and risk, that is, upgrading and continuing operation or replacement. The latter has its problems because of the necessary long lead times before production can be realized.

The United States is a nuclear weapons state; its national security is based on maintenance of a strong nuclear deterrent. The insurance necessary to support that condition over a long period of time requires, in my opinion, at least two first-class, state of the art production reactors, located preferably at two different sites. There is no reason that such new reactors could not incorporate fully acceptable safety concepts.

DOE organization and practice

Over the past two years, great emphasis has been placed on building up the size, strength, and capability of ESH. Reactor safety oversight is one component of its activities. Authority has been given to the Assistant Secretary to curtail or suspend operations at DOE facilities when a clear and present danger exists to workers or members of the public. At the same time, the real responsibility is with DOE operations and especially the on-site contractors.

My report to the Secretary included the following observation:

> "DOE lines of authority and responsibility are multi-layered, long and complex. At Headquarters there are two independent organizational units, Defense Programs (DP) for N-Reactor "operations" and Environment, Safety and Health (ESH) for "regulation," each reporting to the Under Secretary. There is a similar structure at the field office level where the Manager has parallel groups. Yet, the day-to-day operating responsibility is with the contractor. The chain is long, complex, and burdened by too many people."

My point is that the operating arm of DOE needs strong technical leadership and support. It needs short, well-defined lines of responsibility. "Working the problem" by extensive and time-consuming staffing at various levels is not an effective procedure. At the present time, because of geographical distribution of the reactor sites, DOE field responsibility for the eleven principal reactors (Navy reactors are not included) is distributed among five different Field Office Managers. At Headquarters, responsibility falls on three different program Assistant Secretaries, each of whom is heavily burdened by diverse programmatic responsibilities, with the ultimate responsibility falling on the Under Secretary.

Any significant safety issue, whether it is raised by the operations side or the regulatory side, requires immediate attention. By definition, a significant safety issue requires Headquarters decision. Thus, in my view, DOE Headquarters must be involved at an early stage. Much can be achieved by providing a Departmental focus for reactor safety operations that has a technical capability at least equal to that of the "regulators." Simplification of decision making procedures is also necessary.

Next Steps

The NAS/NAE Review Committee commissioned by the Secretary should soon provide its report on the N-Reactor. The Committee was also asked to specifically address the issue of hydrogen generation and mitigation. If the Committee raises new safety questions, they will have to be addressed.

The Safety Enhancement Program is in full swing, and, as various action items are completed, tests and checks will have to be performed to assure that the objectives of the program have been achieved. The prerequisite to N-Reactor start-up is a satisfactory readiness review. The immediate focus for Defense Programs and the contractor must be satisfactory completion of those items necessary for start-up and a funded plan of action for completion of the longer term items remaining in the Safety Enhancement Program.

* * * * * *

The **Chairman**. Thank you very much, Dr. Tape.

Gentlemen, one of my pet peeves about the way we run our nuclear safety programs at the NRC is that there are too lawyer/litigation oriented. Do you share that view?

Dr. **Roddis**. Absolutely, sir.

Dr. **Tape**. And Mr. Roddis is the one who has had more experience on that side than I have, but I agree.

The **Chairman**. Well, it seems to me you look at how long it takes to do something with respect to safety in this country, how long it takes to build a nuclear reactor compared to Sweden or Japan, yet their scram rate is considerably better than ours. And it seems to me that much of that is because we spend our time going to court satisfying the requirements of the legal system instead of really having safety engineers who deal with the technology, hands-on people dealing with the real problem. Rather we are dealing with the legal concept about the problem.

Now, Dr. Roddis, of course any judgments on safety are sort of simultaneous questions of safety, national security and cost. None of these are absolutes. I guess safety at a certain point is an absolute. I mean, you cannot exceed certain danger levels even if national security calls for it. But I do not think, as I understand it, we are at those kind of levels. We are still at the balancing question between safety, national security and cost.

Now, your recommendations were, of course, that we not restart the N reactor. And in my appropriations subcommittee on Energy and Water, we took your advice and, of course, had the moratorium until October 1, that to give DOE time to make these improvements. Some of the improvements that your commission recommended, they have done. Others they have not done. They have not called for the containment facility, for example.

Now, undoubtedly this question will face us again probably in the next year's appropriation bill. And the way these things usually run is that a moratorium one year is asked to be extended till the next year and frequently ad infinitum.

Would you give us your view as to whether you expect that DOE will sufficiently comply with your recommendations so that balancing safety and national security and cost that you can say that they should go ahead or whether we should extend that moratorium?

Dr. **Roddis**. Well, sir, it is very difficult for me to comment on that because I have no knowledge other than what is in the public domain of what is being done. I do know that there were some $200 million worth of changes involved in accomplishing all of the recommendations of the various committees including the several additional recommendations which our group made. And I also have heard that the amounts being spent are something in the $50 million range. So, it is pretty obvious that not all those things are getting done.

I would like to emphasize that my first recommendation was that the reactor be replaced as expeditiously as possible. At the time that recommendation was made, the Department was not supporting that. I just heard this morning that they are clearly supporting that replacement.

The CHAIRMAN. By the way, if I may digress a moment there, do you have a clear view as to what kind of reactor we should build? We are being urged by the light water reactor advocates and the HTGR advocates. Do you have a view on that?

Dr. RODDIS. I have some views on that, but they are basically that you should not try to make power and products for your weapons program in a dual purpose machine. I think that the most successful way of making plutonium and tritium is in a reactor that is designed to make plutonium and tritium. And a low temperature Savannah River type reactor, and containment makes a lot of sense. That was the recommendation that came out of a study that was made five years ago on that, 1982, the Glennan report which is in the public domain. The classified piece of it is small, but the unclassified report clearly recommended that.

Why that was not accomplished in 1982 I do not know. It was apparently an economy measure. Then was the time to have made this decision if the plutonium and tritium were really needed. I have no current way of judging that.

Assuming that they are really needed, I do not see why it is going to take us 10 years. We fought a war in less than four years. And those first reactors were built in wartime conditions in as little as 16 months.

The CHAIRMAN. That included design too, didn't it?

Dr. RODDIS. Well, that included not only the design but the development of the idea and a whole lot of technology.

Now, if you try to build a very sophisticated reactor that is going to do power as well as producing materials, you get yourself more and more problems. You have to operate at high temperature. This imposes more burden on you.

So, I would stick with the recommendations of the Glennan panel which was a replacement reactor similar to the Savannah River reactors with some modest design changes, plus putting them in containment, which is the thing that all other operating reactors are in now.

The CHAIRMAN. Now, I interrupted you. You were telling us that the only thing you knew about what they had done with respect to your recommendations is that which is in the public domain. And you were answering the question about how you would—or if you would answer the question how you would go about deciding if you were in our place whether to restart or not.

Dr. RODDIS. Well, sir, one of the points that has not been enormously well-covered in referring to my report—my recommendation actually was to accomplish all of the modifications which were recommended. If this were a commercially licensed reactor and it had been closed down for a safety question, it would not start up again until all of those things had been done.

Now, the Department is pleading poverty. They do not have the money. If this was a utility, they simply would have said, well, then don't start the reactor. And I truly do not think there is any particular urgency, whatever the needs for plutonium and tritium are. There is a pipeline out there that has a certain amount of slack in it.

The judgment as to whether the money should be spent to do this or to simply start out as my original recommendation was and build a replacement reactor now is a judgment that I have not entered into. I have not been a party to any of this.

The **Chairman**. Well, how serious, for example, is the failure to put a containment on? I mean, that is the clearest recommendation and the——

Dr. **Roddis**. I think it is literally impractical to put a pressurized containment on that Hanford N-reactor. You know, you can do anything if you want to spend enough money, but that it is silly there. It would be a lot cheaper and quicker to build a replacement reactor that was in containment, which is basically what I am suggesting.

I did suggest that the zone 1 of the confinement system, which is of about similar volume to most of the containments, which is only a four pound system, be inerted because the principal threat to the integrity of that confinement system is an explosion. There are other threats to it. But that is the principal one. And the only conceivable source I can see of an explosion is a hydrogen explosion. I do not think that a true nuclear detonation, as occurred at Chernobyl, is a feasible—I mean, I do not think it is physically possible in that system. It is a very different system than Chernobyl.

So, one of my recommendations, which I may be alone on—I happen to feel very strongly about the inerting of containments, especially low pressure ones. I think that could have been done. I don't know what the status of it is. It was one of the things that was thrown off to the National Academy of Sciences committee to study, and they presumably are coming up with some recommendations on it. And I have no idea what they are doing.

The **Chairman**. Based upon that which is in the public domain that DOE is accomplishing, do you have a clear view or a surmise as to how serious the safety and environmental threat will be, say, as of next October 1 when this moratorium subsides—in other words, whether it is a clear question or whether it is one of these balancing questions between safety and national security.

Dr. **Roddis**. Well, it is clearly a balancing question, sir, because unless you are going to make plutonium and tritium, the other reactors should not be operating. Now, if you need the plutonium and tritium, then you have got to balance the hazard. The hazard after spending $50 million out of $200 million worth of improvements is, I would presume, less than it was when it was operating before—probably a great deal less. I do not think it is in proportion to the dollars involved.

The **Chairman**. I guess I am trying to get you to sort of rate that hazard for us. It is a hazard—what is the worst that would happen, and what kind of chances are there that it would happen? You know, we try to be exceedingly careful in nuclear matters because the public is very concerned.

Yesterday there was a front page story in the Washington Post about a venting of an amount of radiation that was one- half of one x-ray. And yet, that was a front page story.

Dr. **Roddis**. Down at North Anna.

The **Chairman**. Yes.

Dr. **Roddis**. I am familiar with that, yes.

The **Chairman**. I am sure that this is a greater hazard than that. I guess I am trying to get you to rate that hazard.

Dr. RODDIS. Sir, my feeling is that even a modest emission of radioactivity would be a real threat to the whole nuclear power industry in the country because the public perception of this is exactly as you say, a very small emission. It gets big headlines, and everybody says, well, all those reactors are alike.

So, that was the reason for my prime recommendation, one, to replace the reactor with one that is probably in containment; two, if the plutonium and tritium are really needed short term, to make the corrections which were in total sum $200 million and shut the reactor down to make them.

I have no way of balancing the need of starting that reactor up in October against the amount of money that has been spent and what the plans are for the future. You know, there is just no way I can look at those balances.

The CHAIRMAN. Dr. Tape, would you give us your views on the same question?

Dr. TAPE. Mr. Chairman, I did avail myself of a couple of hours of discussion with some of the defense programs people in DOE to get some feel as to how the program was going. I did not go into detail. I did not try to evaluate short of success or failure what they were trying to do.

I was impressed that the recommendations and the questions that were raised by all the consultants are being addressed. And that to me was one of the principal motivations of trying to look into that.

As far as hydrogen control, mitigation and so on—the problem—I think everyone is in a sense right now waiting for the comments of the Academy committee to see how they come out on that issue. That does not mean that the Department is not addressing it themselves. They have done a lot of work, but the results are awaiting the Academy study.

I might say that before it starts up, it is my impression that there will be what is called a readiness review, and in effect the ESH group, I call it on the regulatory side, will be having another look at the results of everything that has happened in new equipment in place. Obviously when new equipment is in place, you have to check it out and so on.

I think probably my guess is the outcome will be that as far as the safety of the reactor itself, it will be certainly comparable to any of the commercial reactors. I think, Lou, we sort of said that about the accident situation before, and it was the mitigation of a——

Dr. RODDIS. As far as the chances of an accident occurring, it is about the same. But the accident, if it does occur in a commercial reactor, is contained. And therefore, the consequences on the general public are, oh, a factor of anyplace between 2 and 100 times less. It depends on the accident.

The mitigation is the thing that does not exist fundamentally because of the non-containment. And I think that there was no disagreement among any of the consultants or, for that matter, anyone else that I have seen that has ever said that that reactor has not been operated in a reasonable fashion. It is the design problem, its lack of containment, that is the problem.

The CHAIRMAN. And you had recommendations that would have dealt with that mitigation problem.

Dr. RODDIS. To the extent that it was reasonably feasible to do in an existing reactor. As I say, my prime recommendation was why don't we replace it, which we studied and should have done in 1982.

Dr. TAPE. My comment on the replacement, one, supports what Mr. Roddis is saying. In my statement I do have a paragraph—just in a very oversimplified way, as far as I am concerned, the United States is a nuclear weapons state. It is dependent on a nuclear deterrent. If we are going to have that posture for the indefinite future, we need an insurance program that says if we need the material, it is there, and not that we say, oh, yes, we need it and take whatever it is—5, 10 years—to get it. That is not the way the world runs today.

And so, if I look ahead recognizing that N-reactor is aging, the Savannah River reactors are aging, my outlook, if you will, for some years hence is there ought to be two first- rate reactors in the country capable of producing defense materials. And I would hope that they were in two different locations. And again, I am looking at it as a straight national security insurance-type program.

The CHAIRMAN. Well, gentlemen, I have got to go be on a television program. And Senator Evans has agreed to run the rest of the hearing. I want to thank both of you not only for your testimony today, but for your service to the country on analyzing this problem for us.

And I would seek further advice from you between now and the time we have to make these legislative decisions because they will be very high pressure decisions. There will be people on both sides who will say it is okay, it is not okay. And as far as I am concerned, both of you gentlemen have very high credibility with us, and I think with the American public. We do not want to rush headlong into doing something that is unsafe.

I am very much like you, Dr. Roddis. I mean, you have got a safety problem, and you have also got a perception problem. And if we sent out a couple of rads of radiation, it might not hurt anybody, but it might hurt the whole defense program and further make people uncomfortable with this program. And in peacetime there is no need to exceed a certain discomfort level with nuclear energy or with anything else.

So, I thank you very much, gentlemen, and we will be seeking your further advice as time goes on.

My apologies to Dan Reicher and the Natural Resources Defense Council for not being able to hear that testimony. I very much wanted to be able to do that. And I will check with staff on what was said, and we will take very much into consideration what you have to say. But television beckons.

Thank you very much, Senator Evans, for chairing the hearing.

Senator EVANS. If television beckons, you can always resist the beckoning. But I have never seen any of us yet who are willing to do that.

Mr. Roddis, let me start with the same—to see whether you agree on the record with the recommendations of Mr. Tape on the future. His summary at the end of—his belief that we ought to have two new reactors at different locations, maybe of different types, to have a redundancy in nuclear defense production. Would you generally agree with that?

Dr. RODDIS. I would agree 100 percent. Jerry said it just right.

Senator EVANS. Let me try to put to rest, if I can, or if it is correct to put it to rest, the waving of the Chernobyl flag which seems to be common. Because both the N-reactor and the Chernobyl were graphite or have graphite cores, they have been too often associated as being very similar or even the same in many people's minds.

Is it accurate to say that other than the fact they are both graphite moderated that there are extraordinary differences between the two, and that the dissimilarities exceed the similarities by some distance?

Dr. RODDIS. Oh, I would certainly agree with that. They are both water cooled, and they are both graphite reactors, but beyond that, there is just a whole host of differences in the design. The design of the N-reactor deliberately was made under-moderated so that loss of coolant creates a negative reactivity situation. The Chernobyl reactor is exactly the opposite. And when the water was blown out of that under an absolutely inconceivable set of circumstances, there was literally a nuclear explosion, a very small one, but enough to disassemble the reactor. That simply could not happen in the Hanford machine.

Dr. TAPE. Yes, I agree. Some additional features too. The very fast acting shutdown system of the N-reactor and other features too.

Senator EVANS. So, in blunter terms those who continually try to associate the two together are like someone saying that a mouse and an elephant are the same because they both have four legs. It is just about that level of similarity.

Dr. RODDIS. Maybe a horse and elephant, sir.

Senator EVANS. A small horse.

Mr. Roddis, do you generally have confidence in the National Academy of Science investigative panel and whatever recommendations they may make on the N-reactor and the Savannah River reactors, for that matter, in terms of their continued operation?

Dr. RODDIS. Well, I have had only one discussion with them and that was a presentation of my recommendations. I know I guess all of the members, certainly nearly all of them. I have a great deal of respect for them and their ability. And I am sure that they will come out of the process of the Academy, which in addition to the panel itself involves a rather extensive outside review of people in the hierarchy of the Academy.

So, yes, I think it will be a good statement. And without in any way knowing what it is, I would be greatly surprised if I didn't agree with it.

Senator EVANS. Mr. Tape?

Dr. TAPE. I too have respect for the Academy's work and the panel and so on.

I will make a general comment not specifically to that report. But my own experience on advisory committees, having served on them and having received their reports, is that one never takes every recommendation without question. So, I think it is up to the recipient to examine the report, to examine the assumptions and make sure that, indeed, there is general agreement, or if there is a difference of opinion, one should be able to talk it out.

Senator EVANS. But as far as you know, the confidence of the participants, their access to material, their freedom to investigate what is necessary to make the recommendations are all appropriate.

Dr. TAPE. Right. I see no reason to downgrade or denigrate the committee.

Senator EVANS. Containment is an important safety feature I think we would all agree. Is it not true there is no containment or at least not containment of the kind we are talking about at any of the Savannah River reactors, as well as the N-reactor?

Dr. RODDIS. That is correct, sir. There is a significant difference in that those reactors are operated as plutonium or tritium producing facilities only at low temperatures. So, they do not have the inherent contained energy of the high temperature water. And also any reaction that does occur between the fuel or the cladding would take place at a much slower rate.

So, while I would like to see any replacement reactor down there—after all, I live 100 miles downwind from them.

Senator EVANS. I understand that.

Dr. RODDIS. I would like to see any replacement reactor in a proper containment. I am not nearly as concerned about a nonpower producing reactor operating at lower temperatures.

Frankly, I think the problems down there are much more related to the tritium emissions from the separation plant, which is a wholly different problem.

Senator EVANS. But there are apparently problems sufficiently grave that the reactors all operating at about half power at the current time. Isn't that correct?

Dr. RODDIS. Yes, sir. This was an interesting thing that was turned up first by DuPont. When they reexamined for the National Academy committee the safety systems, it turned out that the capacity of them was less than they had thought so that I think it is prudent right now until the matter is studied further to operate them at the lower power.

Senator EVANS. So, in essence, we have got a national system of four old reactors, none of them contained, all of them headed for the end of their useful lifetimes, and any or all of them potentially subject to a more immediate shutdown if further deficiencies or difficulties were found. Is that generally a picture of where our nuclear production facilities are?

Dr. RODDIS. I am afraid that is true, sir.

And as I say, I happen to have been involved in a very peripheral way in the Glennan panel work studying the replacement reactor issue in the 1982 time frame. And my participation terminated with the report, and I never have been able to understand why the government did not move forward at that time to start the replacement because it was very clear then that replacements were needed.

And Jerry's recommendation that you have them in two different locations—I was a participant in the early 1950s when the decision was made to move from Hanford to another location, and Savannah River was the one that was settled on. I think it is very important strategically to have them in two places. And I am not at all unhappy to have two different reactor types involved.

Senator EVANS. It is the redundancy that is——

Dr. RODDIS. It is a redundancy of the system that is a national——

Senator EVANS [continuing]. Important for national defense.

Dr. RODDIS [continuing]. Defense system. It should not be tried to be justified on return or how much money we can make by selling the power off of it. It ought to be justified on what is the best way to make plutonium and tritium in the most efficient and safe fashion.

Senator EVANS. You mentioned on page 2 of your comments that "With these changes operation at the present power levels and core loadings can continue until 1990 or 1991 without risks increasing much over those now existing."

With the changes, would it be maybe more accurate to say that with risks somewhat less than those now existing rather than increasing much? Doesn't this assume that you are going to implement the safety recommendations that you were talking about?

Dr. RODDIS. All of them or the portion that is——

Senator EVANS. Well, this was your——

Dr. RODDIS. My recommendation was they all be implemented, sir.

Senator EVANS. Yes.

Dr. RODDIS. Including some additional ones beyond the 88 that were recommended. I do not know how many of the 90 or 95 recommendations in total are going to be accomplished by October.

Senator EVANS. Well, I understand that. But in your statement here you are saying "with these changes." Presumably that means the changes that you had just recommended up above.

Dr. RODDIS. With all of them.

Senator EVANS. But with those changes, we have got then a reactor that presumably is safer or significantly safer than it is today. Wouldn't it be accurate to say that you can operate it until 1990 or 1991 with risks somewhat lower than those now existing?

Dr. RODDIS. Well, the reactor is getting older, and the unknowns concerning the condition as time passes with both the graphite and the pressures on the zirconium tubing are negatives to that.

Senator EVANS. Would it be accurate to say then that the continued operation of the Savannah River reactors can be carried forward without risks increasing much over those now existing? They are getting older as well.

Dr. RODDIS. We did not look at Savannah River.

Senator EVANS. I know, but just inherently if you are saying as a reactor gets older, the risks increase, then it would flow from that.

Dr. RODDIS. To that extent, I certainly agree. The older the reactor gets, unless mitigating steps are taken, the risk goes up not necessarily rapidly.

Dr. TAPE. I was going to comment, Senator Evans——

Senator EVANS. Please.

Dr. TAPE [continuing]. That there were two major areas there, the question of process tubes and graphite growth, for example, that concern many people. And one recognizes that that is probably a determining factor in the ultimate life of the reactor. And as they age, it simply to me means one as to pay more attention to those than one did in the first 10 years, for example. And that—I can't say whether it is 91, 92, 93, 94, but is the sort of thing that one keeps on top of, and more emphasis is placed there.

I think probably I would express myself a little different than Mr. Roddis in the following way. And perhaps I was hedging in my recommendations. Some of the points that we raised were in my mind questions as to whether we had sufficient information to make statements about the safety. So, many of the things that are being done today as part of the program are analyses to try to determine whether or not the basis on which prior judgment was made are still valid or whether they are worse or whether they are better.

Senator EVANS. Yes.

Dr. TAPE. And in part, to answer your question, I would rather see the outcome of those analyses before I say yes, it is better or worse.

Senator EVANS. Sure, okay.

Dr. TAPE. And I think the readiness review will bring those out.

Senator EVANS. Dr. Roddis, you have had a lot of investigation and have made a number of comments on hydrogen and the hydrogen mitigation system as being perhaps the single most important or critical element in the safety requirements.

Now, you have recommended a hydrogen inerting system. It is my understanding that the Department is looking at a hydrogen ignition system as an alternative. Are there several alternatives that would adequately handle the problem in your view as opposed to just the inerting system itself?

Dr. RODDIS. Well, the issue of inerting versus a burning system fundamentally is the difference between a passive system and an active system.

In the whole issue of reactor safety, I am very much in favor of passive systems. The weaker containments, the suppression systems, in the commercial reactors are all inerted. In at least one case, it also has a burning system. It is a belt and suspenders arrangement. I have known of a couple of instances where on surveillance the burning system was not functioning.

On the other hand, I have to confess that I am probably at one extreme of this position. There are people who are quite comfortable with the burning systems. I personally feel much more comfortable with an inerted system because once it is inerted, it is there. And since you cannot enter that area anyhow or you should not be entering that area anyhow, I do not see that it imposes that big a problem.

When the inerting was started on the GE reactors, there were a lot of people who were very unhappy with it. I think most of the operators have come to accept it. As a matter of fact, it has some advantages. It holds down corrosion in the whole system.

Senator EVANS. Well, this has been a very, very helpful panel. We are delighted that you have agreed to come back again. I think you are contributing an extraordinary amount beyond anyone's expectations to this very tough and troublesome problem. And I know that your recommendations, both of yours, will be looked at with very careful consideration by the committee.

Oh, I am sorry.

Senator **Wirth**. Thank you, sir.

Senator **Evans**. Senator Wirth has come in.

Senator Wirth.

Senator **Wirth**. There is always danger in delegating the Chair to the minority. [Laughter.]

Mr. Roddis, let me ask you, if I might, as I understand it, your recommendation is that Hanford be closed down. Is that right?

Dr. **Roddis**. My recommendation is that if the only need for Hanford was for the power generation, that it should be closed down permanently, that it should be replaced as soon as possible if the production is needed for military purposes, and that if the production is needed for military purposes in the interim until a replacement reactor can be built, that some rather large number of changes and studies and a number of other things be accomplished.

Senator **Wirth**. Let me come at it then in a different way. Do you know, is there a national security reason for keeping Hanford open?

Dr. **Roddis**. You are asking me a question I cannot answer, sir.

Senator **Wirth**. What has DOE said to you?

Dr. **Roddis**. The DOE says—I believe their position is that there is a need for the plant to operate.

Senator **Wirth**. And on what do they justify that, do you know?

Dr. **Roddis**. Sir, I cannot speak for the DOE.

Senator **Wirth**. It is your argument, as I understand it, that if something—or part of the argument—that were something to happen at Hanford, were there to be the worst case accident, or even a less serious accident that that would be very destructive to the nuclear industry in the United States overall.

Dr. **Roddis**. Sir, I do not think it even has to be a half worst case. I think it could be a very minor problem and still create a very serious threat to the continued operation of a lot of other reactors.

Senator **Wirth**. How has the industry overall reacted to that statement? Does the industry agree with you?

Dr. **Roddis**. I have made no attempt to——

Senator **Wirth**. Well, you have not heard any reaction.

Dr. **Roddis**. No. I think everybody is worried. There is a very common saying in the nuclear utility industry that we are all hostage of each other, that what happens in one plant is going to affect all of us. And that is why the nuclear utilities and the DOE operations are especially worried about anything that might happen.

Senator **Wirth**. Is there a need for the power that comes out of the Hanford in the northwest part of the United States?

Dr. **Roddis**. No, sir. My report goes into that. I think that is an area that I am competent to make judgments in because of my background. And there is a brief analysis in there of the effect of shutting down the power producing capability of the N-reactor. And I conclude that for at least two decades it is of no significance.

Senator **Wirth**. So, we are really talking about a national security issue.

Dr. **Roddis**. Yes.

Senator **Wirth**. And Hanford produces plutonium and tritium. Is that right?

Dr. RODDIS. At the moment it has been producing plutonium and very modest amounts of tritium in an experimental basis. This is one of the points I made in this morning's statement. We did not look at the operation of that reactor with a highly enriched load and tritium targets, lithium aluminate targets, as a major tritium producer.

I have some concern that under those circumstances the reactor may not be as stable. But it simply——

Senator WIRTH. If the reactor were—you can figure the reactor to produce tritium or plutonium, it might be less stable if it had a major responsibility for producing tritium. Is that right?

Dr. RODDIS. I do not know.

Senator WIRTH. It could from an engineering perspective.

Dr. RODDIS. It could from a reactor physics standpoint. That could occur. We inquired about that. It has apparently not been—as of last July when was the last time we were talking to the people involved, it had not been studied in any detail, and I have not followed it since then.

Senator WIRTH. And you have pushed the edge of my technical capability beyond its firm foundation. But what it seems to me we ought to do is to ask DOE. This is an important issue if we are looking at how important Hanford is for national security, that if on the one hand, the need is to create more plutonium, then we have to say, okay, what is the justified need for more warheads that are going to need more plutonium. I mean, that is a national security question.

Dr. RODDIS. Yes, sir.

Senator WIRTH. And I think there is an awful lot of evidence on the issue. I would argue that we have got plenty of plutonium around. We have a significant amount of plutonium around. Particularly if we reach some kind of an arms control agreement with the Soviets, particularly if we bring back from Europe a lot of the weapons over there that probably should not be there on the ground and reprocess the plutonium, we have probably got a lot of plutonium. But that is not the issue in front of us here.

I think the argument is made that we have to keep Hanford open because the tritium has a very, very short half-life. Is that right?

Dr. RODDIS. It's 13 years, yes. It is the bureaucrat's dream.

Senator WIRTH. Tritium is a bureaucrat's dream. Is that what you said?

Dr. RODDIS. Well, it disappears and you have to make more of it.

Senator WIRTH. Okay, but if Hanford is not making tritium, then you are right back into a plutonium discussion.

Dr. RODDIS. All I am saying, sir, is that the tritium producing mode of Hanford, aside from a modest amount—you can make certainly a small test amount in one or two tubes and have no problem. If it is loaded as a major tritium producer, we simply did not look at what the nuclear hazard was.

Senator WIRTH. We will ask DOE about that. It is very interesting. I thank you.

Let me ask you if you know anything about other parts of the complex that produces weapons, whether that is Savannah River or the plants in Ohio or our favorite, Rocky Flats.

Dr. RODDIS. Well, I obviously have pretty general knowledge of it having participated in it since 1946 one way or another. But I have not in recent years, aside from the look at the N-reactor, had much to do with the production chain. I did mention that in the Glennan report in 1982—at that time I was chairman of the Energy Research Advisory Board. And I was asked to look at that report and its actions, and I did. But I have not been close to the production chain since I left——

Senator WIRTH. When was Hanford built?

Dr. RODDIS. Early 1960s.

Senator WIRTH. Early 1960s in Hanford.

Dr. RODDIS. Yes.

Senator WIRTH. Just by parallel——

Dr. RODDIS. That is the Hanford N-reactor was completed in the early 1960s. Of course, the first reactor at Hanford was built in 1944.

Senator WIRTH. The N-reactor at issue here was built in the 1960s.

Dr. RODDIS. Early 1960s.

Senator WIRTH. Early 1960s.

Dr. RODDIS. The design is, let's say, 1957, 1958.

Senator WIRTH. Mr. Tape.

Dr. TAPE. The nuclear power portion was built in that time. The steam facility generating capacity was built slightly after.

Dr. RODDIS. That is right. The steam generation and the power production was added I think in——

Dr. TAPE. I can remember it because I was present when President Kennedy broke ground for the steam plant in 1963.

Senator WIRTH. Just by way of comparison, I might note that Savannah River was largely built in 1950 I understand.

Dr. RODDIS. Yes, sir.

Senator WIRTH. Rocky Flats in 1951.

Dr. RODDIS. Yes, something like that.

Senator WIRTH. Fernald in 1952.

Dr. RODDIS. Yes, sir.

Senator WIRTH. What we have here—and I think one of the issues that we are going to be getting into is that we have is a very aging, and I think potentially a very, very dangerous set of facilities.

Dr. RODDIS. Yes, sir.

Senator WIRTH. And the Department of Energy and the Congress have paid precious little attention to the fact that we have this very aging and I would suggest increasingly dangerous set of facilities out there, and that we have to figure out some way in which we can really move on this issue and make the investment that is critically needed. Making the investment gets at the low end of the scale every time. I mean, it is the last priority to focus on what it would cost to replace Savannah River or what it would cost to make changes in Ohio or in South Carolina or in Colorado.

Dr. RODDIS. Yes. Your Rocky Flats facility is certainly one that needs a lot of work.

Senator WIRTH. It needs an enormous amount of work. That is right.

Dr. RODDIS. Yes, sir.

Senator WIRTH. And the question we then face is do you pour good money after bad, or do you put a lot more money back in trying to fix up that facility? Or do you follow what I gather you are suggesting that—absent national security concerns, and absent the need for power, what you end up doing is saying, okay, let's stop this now. Let's not do any more here and let's start de novo someplace else.

Dr. RODDIS. I certainly agree completely with Dr. Tape's position. We are a major nuclear power. In order to maintain a credibility, we ought to keep our facilities up. We have not done so. We have not put the money in them in the last 25 years really that we should. It is a national problem. It is in no sense a political problem.

And we ought to decide now—and I hoped in the early 1980s that we were moving on the track of doing this, and then it got derailed. But we ought to make up our mind that if we are going a major nuclear power, that we better keep our powder dry. And that means quite a lot of money in a number of facilities.

Senator WIRTH. I could not agree with you more, and the question then is how do we do that. Where do we spend that money, where is the wisest place to do it? Do you want to spend money taping together old facilities, or do we step back and say, let's take a look at this whole operation based upon what we know in 1987, significantly different from what we knew in the late 1940s, early 1950s when all of this was designed and built?

Dr. TAPE. And whatever the plan turns out to be, it is a plan for the next century.

Senator WIRTH. That is right. And it is going to be very expensive too. It is going to be very expensive, but it has to go on for a long period of time. For example, nobody would put Rocky Flats where it is today, you know, in 1987. But it was done in 1950, and there was a wonderful——

Dr. RODDIS. In 1950 it was way out in the country.

Senator WIRTH. Well, it was, as a matter of fact, supposed to be much further out in the country.

Dr. RODDIS. Yes, I know it was.

Senator WIRTH. And the local chambers of commerce and the city lobbied to have it moved in closer. I have the headline from the Rocky Mountain News the day that the award was made that it would come and "A Plant Comes to Denver," and man-on-the-street interviews of jobs and so on. That is a different era than we see in 1987.

Let me ask you a final question, and that relates to responsibility for health safety and the environment in these plants managed by the Department of Energy. It seems to me and it has seemed to be for some time that we have something of fox in a chicken house syndrome. Not only is the same operation, the same office, that runs these plants responsible for health and safety, but that only exists within DOE. Maybe we should separate it within DOE, but also maybe we ought to take some of this out of DOE and put it someplace else.

Do you have any thoughts about that?

Dr. RODDIS. My position, I thought I had made clear, was that first I think that the office that Mary Walker has, the Assistant

Secretary for Environment, Safety and Health, should be made a statutory position so that there is a separate, distinct office at the assistant secretary level that is concerned with those matters. I believe Secretary Herrington deserves a great deal of credit for putting that office in place and making it effective.

Senator WIRTH. I agree.

Dr. RODDIS. But I think it ought to be a statutory office so somebody else cannot change it.

And secondly, that there should be some form of outside overview. And my suggestion was to make use of the outside overview that the old AEC had in the ACRS. But I think some form of an outside overview is needed.

I have not examined any of the two or three bills that are floating around or have not discussed the potential suggestions from the Department. But I think there should be some form of an outside overview.

Senator WIRTH. And there have been some that argued that the health functions ought to be—health monitoring functions and so on ought to be taken out of DOE altogether, that that is not DOE's expertise and you ought to put it truly on the outside so you get a truly independent view.

Dr. RODDIS. Well, this relates to the question you were asking earlier, sir, of the environmental people about their position vis-a-vis another government department. I mean, the same problem exists in the nuclear safety issue as exists in the overall environmental issue.

Senator WIRTH. Sure.

Dr. RODDIS. And the environmental issue—a lot of it has been taken out of the Department and put in the hands of EPA. Certainly that approach is a possible one.

I think that for the 11 reactors involved it is probably simpler to have an outside overview body. And apparently the National Academy of Sciences is trying to do this in a realistic fashion.

Senator WIRTH. Mr. Tape?

Dr. TAPE. I would comment that your point about the fox in the chicken coop again is a perception-type problem that we had back when AEC had both functions and it was split, ERDA-NRC, now DOE-NRC. And from a perception point of view, that has probably been a success. I do not necessarily think it has been a success on other grounds.

I understand the perception problem, but I also think that there is a lot to be said for having the safety responsibilities close to where the expertise is also. And that is one of the advantages of having a somewhat closer coupling. So, I think it feasible to do it, but there is the perception you are talking about. There is an overview type question which I think is important of external type independent.

I said earlier in this hearing that I was uneasy about creating a new independent agency with still more layers of this oversight.

Senator WIRTH. I understand.

Dr. TAPE. And I would just enter a plea of can't we do it in the most effective, simple way without trying to get more and more layers.

Senator WIRTH. I agree with that. And what I was thinking about was less safety and more health. I was thinking about the very technical parts of health monitoring and the health standards and so on being set outside of the Department of Energy which does not have that expertise. NIH does. The National Cancer Institute does.

Dr. TAPE. I would say in nuclear areas the Department has a lot of expertise.

Senator WIRTH. They do. That is what I am trying to say. If that capability exists there and if that is adequate, that is the best we can do—and your suggestion is maybe the most important thing is get what you can get. And at this point the important thing to do is to set up by statute Ms. Walker's office and do it that way, that that would be the most important——

Dr. RODDIS. And an outside advisory group—

Senator WIRTH. With an outside monitoring advisory panel.

Dr. RODDIS [continuing]. By statute also.

Dr. TAPE. It could be an ACRS-like system—also statutory.

Senator WIRTH. Thank you very much, Senator Evans. Thank you very much. I appreciate your all being here.

Senator EVANS. Thank you. Just two final comments. It seems to me that as we talk about danger, we could find ourselves with the most dangerous position of all being one in which all defense facilities were shut down and we were left with no capability to react. That would be a unilateral nuclear disarmament of an extraordinary proportion that I do not think this country is prepared to take. And that might be the ultimate danger far exceeding the dangers from the operation of any of the reactors.

And although I enthusiastically agree with Dr. Roddis that it should not take 10 years to design and build a new reactor, there is no question in my mind that external forces will insure that it will take at least 10 years to go through the process and to get a new reactor. And so, I think we have a significant potential window of vulnerability here that we have got to make sure that we can bridge in some fashion. I would say to my colleague from Colorado that it is not necessarily true that the N-reactor produces power that is not needed in the northwest. That depends very much on the kind of water year and all of the circumstances. This year I suspect that we will find before the fall is up that the N-reactor will indeed be an important ingredient in the Pacific Northwest power picture because we are at least partially through one of the lowest water years in the northwest history. And unless there is some unusual rainfall, we might very well need that production. So, it is not that it is needed every day or even every year, but it is an important ingredient on some years. And this happens to be one of them.

Thank you very much.

We will now turn to the last panel, Mr. Dan Reicher, Attorney for the Nuclear Project for the Natural Resources Defense Council, accompanied by Dr. Thomas Cochran, Senior Scientist for the NRDC.

Senator WIRTH. Senator Evans, while we are waiting, we might get the committee staff to follow up on what Dr. Roddis was suggesting in terms of the national security requirements so that we would better understand the distinction which he and Mr. Tape were making between tritium and plutonium.

Senator EVANS. Virtually all of that would have to be done in executive session——

Senator WIRTH. I understand.

Senator EVANS [continuing]. Because it is all fairly highly classified.

It is useful. I know I have had three separate briefings myself on that particular issue in order to get better acquainted with the issue. And I think that is always available to any of the members. And I think it is a very useful thing to do.

And I suspect as we move a little farther along, that it would be helpful to have either that kind of classified briefing for the committee or in some—I do not quite know just how we would do that through the staff. We would have to do it so whatever report that would be of any value would carry the same level of classification as—

Senator WIRTH. Let's keep that in mind. I think that is going to be part of this whole package that we are trying to get our hands around here.

Senator EVANS. I think it is terrible important. And I found from the briefings that I have had that things are nowhere near as simple as they sometimes appear to be at the surface.

Senator WIRTH. They never are.

Senator EVANS. They rarely are. And this is certainly a circumstance. And it makes it very difficult because we sit here in open hearings and we have conversations back and forth about whether there is or is not need. In fact, I suspect we will have that conversation here very quickly—whether there is or isn't need for plutonium or tritium. And not having access to the kind of classified briefings that make things much more complex than they otherwise seem.

With that, who wishes to start? Mr. Reicher?

STATEMENT OF DAN W. REICHER, ATTORNEY, NUCLEAR PROJECT, NATURAL RESOURCES DEFENSE COUNCIL, ACCOMPANIED BY DR. THOMAS COCHRAN, SENIOR SCIENTIST, NRDC

Mr. REICHER. Yes. Thank you, Senator Evans, Senator Wirth.

I am Dan Reicher. I am attorney with NRDC's Nuclear Project. I hold a law degree from Stanford University, and formerly was an assistant attorney general for environmental protection in Massachusetts, a staff member of the President's commission on the accident at Three Mile Island, and a legal assistant in the hazardous waste section at the Justice Department.

Accompanying me is Dr. Thomas Cochran. Dr. Cochran is a senior staff scientist at NRDC. He holds a Ph.D. in physics from Vanderbilt University and was a member of DOE's Energy Research Advisory Board, DOE's Nuclear Proliferation Advisory Panel, and the Nuclear Regulatory Commission's Advisory Panel for the Decontamination of the Three Mile Island Unit 2. He is also an editor and co-author of the Nuclear Weapons Databook series, including the recently published volume II, U.S. Nuclear Warhead Production.

Senator **Evans**. Mr. Reicher, the whole statement will be included in the record.

Mr. **Reicher**. Yes. I am going to give a substantially abbreviated version.

Senator **Evans**. Thank you.

Mr. **Reicher**. We are announcing this morning that we will be filing suit later today in the Federal court in Spokane, Washington to force DOE to prepare an environmental impact statement on the decision to restart the N-reactor prior to resumed operation of the facility. We will be joined in the litigation by Senators Adams and Hatfield, Congressmen Bonker, Lowry, AuCoin and Wyden, and 11 public interest organizations.

In December of last year, following DOE's shutdown of N-reactor, we filed a notice of intent to sue the Department to force it to prepare an EIS on the proposed renovation and restart. The N-reactor has never been the subject of an EIS unlike virtually every commercial nuclear reactor which has gone on line since 1969.

In February Assistant Secretary Walker advised us that DOE had decided to prepare an EIS. However, that EIS will only consider the environmental impacts of the operating reactor with and without the renovations. It will not consider the question of whether the N-reactor should be renovated and restarted at all, nor will it consider alternatives to the proposed renovation and restart, including permanent shutdown, shutdown with restart only in the event of a national emergency and reliance on existing plutonium stockpiles.

DOE's actions with respect to the EIS make a mockery of the National Environmental Policy Act which is our basic national charter for protection of the environment. The Department has chosen to ignore its responsibilities to look before it leaps into costly renovations and the potentially catastrophic start-up of a reactor which is the most similar of U.S. plants to the Chernobyl reactor and which even DOE admits has a remaining useful life that does not extend beyond the mid-1990s.

This would not be the first time that we have been forced to go to court to force DOE to own up to its NEPA obligations. In 1982 DOE argued that it did not have to prepare any EIS on its proposal to restart the N-reactor at the Savannah River plant. U.S. District Court Judge Thomas Penfield Jackson disagreed holding that DOE had to prepare a full EIS prior to the start-up of the N-reactor.

And I would note that preparation of that environmental impact statement took about 10 months. And that is contrary to the 18 months to three years that Mary Walker talked about earlier.

An EIS would answer comprehensively and publicly the hard question which DOE has so far avoided—that is, when the safety and environmental impacts of N-reactor operation are balanced against the need for plutonium from the plant, is renovation and restart justified. Unless and until Congress and the American public have a full answer to this question, we believe that N-reactor should not be restarted.

Based on available data, we believe DOE has a very difficult burden in proving that N-reactor should be restarted. All agree that if N-reactor cannot operate safely, it must not be restarted. Where there are differences, however, is over what constitutes a safe reactor. Our view is that the Nuclear Regulatory Commission safety standards for commercial reactors provide the minimum acceptable level of safety for any power or production reactor in the United States. If the N-reactor following renovation cannot provide a level of safety equivalent to that required of commercial power plants, it should not be restarted. And if there was one message which came through loud and clear from the Roddis Panel which investigated N-reactor it was that the N-reactor does not meet NRC safety standards.

The impacts of a severe accident at the N-reactor may be exacerbated by inadequate emergency planning. We have not considered emergency plans for the N-reactor in detail. However, we have studied in detail similar plans for the Savannah River plant reactors.

DOE assumes in its emergency plan at the Savannah River plant that populations outside of two small areas less than two miles from the boundary of the site would not have to be given immediate warnings or be the subject of protective actions in the event of an accident.

On-site DOE assumes that in a worst-case accident, there would be no deaths and only 400 employees out of a total work force of 15,000 would receive radiation exposure, and that exposure would be below levels causing radiation sickness. Clearly in light of Chernobyl, these assumptions are simply indefensible.

On top of the risk of catastrophic accidents at N-reactor must be added impacts on the environment from routine operation. Among these are thermal discharges. The N-reactor discharges 450 million gallons per day of hot water to the Columbia River. Concerns have been raised by Federal and state agencies regarding the ecological impacts of these discharges particularly on salmon. Moreover, documents reveal the N-reactor has violated its Clean Water Act permit on an average of 23 times per year for the past 5 years.

Equally troubling, DOE seems to have reported fewer violations in its monthly discharge monitoring reports to EPA.

Finally, DOE has failed to meet an important Clean Water Act permit condition requiring it to either bring N-reactor discharges into compliance with the state standards or seek a variance.

In view of these substantial violations of the Clean Water Act, we filed a notice of intent to sue DOE in June of this year. And we are prepared to file suit at the end of the 60 day notice period to force full DOE compliance with the Clean Water Act prior to any restart of the N-reactor

Turning to the need for plutonium, the DOE has defended its decision to restart N-reactor despite the reactor's significant safety impacts citing the need for plutonium. Our research, however, has shown that the plutonium which could be produced at N-reactor over the remaining years of the plant's useful life is not needed to meet DOE nuclear warhead production requirements. Rather, by increasing the retirement of obsolete warheads by about 10 percent each year—i.e., 150 warheads out of the 1,500 to 2,000 retired annually—we would obviate the need for the restart of the N-reactor.

Members of Congress have for years called on the Department of Defense to increase the rate of retirement of obsolete weapons. Even the DOD would be hard-pressed to argue that the security of the United States would be threatened by an arsenal containing 24,850 instead of 25,000 warheads.

DOE may argue that additional plutonium from N-reactor is needed for so-called surge capacity—i.e., to provide a cushion in the event of a drastic increase in Soviet production. However, DOE already has on hand a sizeable reserve, several tons of plutonium for this purpose.

In addition, there is an additional surplus of several tons of weapon-grade plutonium in the form of scrap. The available scrap is believed to exceed the total plutonium production that could be produced by N-reactor over its remaining lifetime were it restarted. In other words, by judiciously mining the plutonium scrap, the restart of N-reactor could be avoided even without accelerating retirement of obsolete warheads.

In conclusion, the safety and environmental risks of the N-reactor operation are substantial and exceed those of commercial nuclear power plants. The plutonium that would be produced by the plant during its limited remaining useful life is not necessary for national security. On balance, these facts raise serious questions about whether the N-reactor should be restarted. The Senate Armed Services Committee recently concluded that N-reactor should be mothballed and restarted only in a national emergency.

The Senate Energy and Natural Resources Committee should give serious consideration to this conclusion and the facts that support it.

And I would ask Dr. Cochran if he has an additional comment.

Dr. COCHRAN. Senator, I would just like to elaborate on what I think are the two principal issues that have been discussed this morning, the need issue and the safety issue. And despite the fact that much of the information with regard to need is classified, there are a few facts that are not classified that allow us to put that in perspective.

At the end of the Carter Administration in about 1979, there were approximately 25,000 or so warheads in the stockpile, give or take 1,000 or 2,000. And the administration then was looking at significant growth in the stockpile over the out-years. And even with the incoming Reagan Administration, the projections were very similar. And in fact, they were projecting something like a 13 percent increase in growth of the stockpile over 5 years.

Now, as a consequence, from 1979 through about the early 1980s, the Carter and then the Reagan Administration looked at all sorts of initiatives for increasing the plutonium production and also tritium production because of the neutron weapons that were coming on line, and in fact, implemented a large number of initiatives to increase production, and in fact, by 1985 had doubled the plutonium production output of the complex.

But as it has turned out, the stockpile did not increase over the Reagan years and, in fact, has gone down. And that fact is unclassified, and is a consequence that we have built up a surplus of plutonium that can serve as a reserve.

And therefore, in our view you really cannot make the case for the continued operation of the N-reactor for another 5 years based on plutonium requirements. Most of the plutonium for the new builds comes from retirements. Congress has complained in past years about the slowness with which the DOD retires old weapons. And so, there is a large reserve of plutonium just in judicious retirement policy and ample plutonium in the existing reserve.

So, the issue really boils down to tritium. And the N-reactor is not a good reactor for the production of tritium. The N-reactor—the tritium production mode was examined in the late 1960s, and the simple fact is that N-reactor is not as efficient at tritium production as the production reactors at Savannah River.

So, to the extent we need additional tritium, and we of course will because of its decay, it argues at best you might want to mothball the N-reactor. But you certainly can't make an argument for operating the N-reactor in the tritium production mode as long as you have got an operating reactor at the Savannah River plant.

Now, I might point out with respect to the Savannah River reactors I agree with the statements that have been made about those reactors. They are old and they could be shut down at any time due to safety problems.

I would point out that the power level that—it has been stated publicly that they are operating at half power. That is half the power after the power level was increased substantially during the Reagan Administration. So, in fact, the power level they are operating now is perhaps 75 percent of the power level they were operating under during the Carter years.

So, in sum, I do not think you can make a case for the N-reactor on the basis of need. And similarly, you can't make a case on the basis of safety. As a member of the public and staff of the NRDC, I participated in the licensing process for commercial nuclear reactors at the NRC.

Those of us who have been on the other side in those licensing battles opposing the operation of certain facilities have always thought we were fighting a no-win situation where traditionally the commissioners appointed to the AEC and then NRC—the majority of them have been pro-nuclear. They write the regulations. They pick the judges. They make the final decisions. They have loopholes in the regulations that allow you to defer many issues that are not resolved to do studies and so forth.

But that is the sort of test for safety in the United States. When it comes down to it, we have one test for what constitutes a safe reactor, and that is whether it can be licensed by the Nuclear Regulatory Commission. The N-reactor from the day it was turned on on the last day of 1963 until today could never meet the licensing requirements of the AEC or the NRC because of the lack of sealed containment. It may be that you could have made modifications at one time and met regulations. But in fact, it was never done. Until this day it is not licensable.

With the improvements that are being proposed by the DOE, only part of which will be implemented by the time they propose to turn it on—even with those improvements, it would still not be licensable by the Nuclear Regulatory Commission. So, it does not pass the central test of whether this reactor is safe.

Our position is the reactor is not safe. You cannot make a case for the need for it. And therefore, we agree with Mr. Roddis that the reactor should be shut down.

That concludes my remarks.

[The prepared statement of Mr. Reicher and Dr. Cochran follows:]

Natural Resources
Defense Council

1350 New York Ave., N.W.
Washington, DC 20005
202 783-7800

TESTIMONY OF

DAN W. REICHER, ESQ.

AND

THOMAS B. COCHRAN, PH.D.

OF THE

NATURAL RESOURCES DEFENSE COUNCIL

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

OF THE

SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES

CONCERNING

PUBLIC HEALTH AND SAFETY ASPECTS OF

OPERATION OF THE DEPARTMENT OF ENERGY'S

NUCLEAR WEAPONS PRODUCTION FACILITIES

July 17, 1987

Washington, D.C.

100% Recycled Paper

New York Office:
122 East 42nd Street
New York, New York 10168
212 949-0049

Western Office:
25 Kearny Street
San Francisco, CA 94108
415 421-6561

New England Office:
850 Boston Post Road
Sudbury, MA 01776
617 443-6300

Toxic Substances
Information Line:
USA: 1-800 648-NRDC
NYS: 212 687-6862

My name is Dan W. Reicher. I am an attorney with the NRDC's nuclear project. I hold a law degree from Stanford University and a bachelor's degree in biology from Dartmouth College. Prior to joining NRDC's staff in 1985, I was an Assistant Attorney General for environmental protection in the Commonwealth of Massachusetts, a staff member of the President's Commission on the Accident at Three Mile Island, and a legal assistant in the Hazardous Waste Section of the U.S. Department of Justice.

Accompanying me is Dr. Thomas B. Cochran. Dr. Cochran is a Senior Staff Scientist with NRDC. He holds a Ph.D. in Physics from Vanderbilt University, and was a member of the Department of Energy's (DOE) Energy Research Advisory Board (ERAB) from 1978-1982; DOE's Nuclear Proliferation Advisory Panel (1977-79); and the Nuclear Regulatory Commission's Advisory Panel for the Decontamination of the Three Mile Island Unit 2 (1980-1986). He is also an editor and co-author of the Nuclear Weapons Databook series including the recently published Volume II, "U.S. Nuclear Warhead Production."

NRDC is a national environmental organization with over 70,000 members and a staff of 100 lawyers, scientists and resource specialists at offices in New York, Washington, and San Francisco. NRDC pursues a broad range of environmental, energy and defense issues. NRDC has long been concerned about the environmental effects of DOE's nuclear weapons production complex. Over the past 12 years, the NRDC Nuclear Project has won a series of lawsuits to enforce federal environmental laws at

DOE facilities including Hanford, Washington; Oak Ridge, Tennessee; and the Savannah River Plant, South Carolina.

In Part I of this testimony we address NRDC litigation to force DOE to prepare a full environmental impact statement (EIS) on the restart of the Hanford N-Reactor. In Part II we consider some of the issues surrounding the question of whether the N-Reactor should be restarted. In Part III we comment briefly on legislation which has been introduced providing for outside regulation of DOE facilities.

I. Hanford EIS Litigation

We are announcing this morning that we will be filing suit later today in the federal district court for the eastern district of Washington State to force DOE to prepare, circulate for public comment, and consider an EIS on the decision to restart the N-Reactor prior to resumed operation of the facility. We will be joined in the litigation by Senators Adams and Hatfield, Congressmen Bonker, Lowry, AuCoin and Wyden, and eleven public interest organizations.

In December of last year -- following DOE's shutdown of the N-Reactor and decision to spend as much as $200 million on renovation -- we filed a notice of intent to sue the Department to force it to prepare an Environmental Impact Statement (EIS) on the proposed renovation and restart of the N Reactor. The N-Reactor has never been the subject of an EIS unlike virtually every commercial nuclear reactor which has gone on-line since 1969.

On February 9, 1987, DOE Assistant Secretary Mary Walker advised NRDC that the Department had decided to prepare an EIS on the N-Reactor. Our initial enthusiasm with DOE's decision, however, waned when we learned that the EIS will only consider the environmental impacts of the operating reactor with and without the proposed renovations. It will not consider the question of whether the N Reactor should be renovated and restarted at all. Moreover, the EIS will not consider alternatives to the proposed renovation and restart including permanent shutdown, shutdown with restart only in the event of a national emergency, reliance on existing plutonium stockpiles, construction of a new production reactor, conversion of the mothballed WNP-1 reactor, conversion of the N-Reactor to tritium production, or upgrade of the Savannah River Plant production reactors.

DOE's actions with regard to the N Reactor EIS make a mockery of the National Environmental Policy Act (NEPA), which is "our basic national charter for protection of the environment." 40 C.F.R. § 1500.1(a) The Act is overseen by the President's Council on Environmental Quality (CEQ) which has developed a detailed set of regulations to ensure that agencies act according to both the letter and spirit of the law. The CEQ regulati[illegible] which DOE has adopted as its own, state that the purpose of [illegible] EIS is to:

> [S]erve as an action-forcing device to insure that the policies and goals defined in the Act are infused into the ongoing programs and actions of the Federal Government. It shall provide full and fair discussion of significant environmental impacts and shall inform decisionmakers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment.....An environmental impact statement is more than a disclosure statement. It shall be used by Federal officials in conjunction with other relevant materials to plan actions and make decisions.

We believe that DOE is acting illegally in deciding to restart the N Reactor without the benefit of a full EIS. The Department has chosen to ignore its responsibilities to "look before it leaps" into costly renovations and the potentially catastrophic start-up of a reactor which is the most similar of U.S. plants to the stricken Chernobyl reactor and which even DOE admits has a remaining useful life that does not extend beyond the mid-1990's. We believe that DOE must prepare an EIS which considers whether the N Reactor should be restarted and alternatives to that course of action. Moreover, the EIS must be completed prior to the proposed restart.

This would not be the first time that we have been forced to go to court to force DOE to own up to its NEPA obligations in restarting one of its production reactors. In 1982, DOE refused to prepare any EIS on its proposal to restart the L Reactor at the Department's Savannah River Plant. DOE argued, just as here, that it only had to consider the environmental impacts of the operating reactor before and after renovation, and also that it could do so in a far less comprehensive document called an environmental assessment. The federal District Court in Washington, D.C. disagreed holding that DOE had to prepare a full EIS prior to start-up of the L-Reactor. In reaching its decision the court held that: "start-up of any nuclear reactor is treated as a major federal action requiring consideration of environmental effects...even restarts of dormant reactors which have previously been the subject of environmental impact statements (sic)." NRDC v. Vaughan 566 F. Supp. 1472 (D.C.D.C. 1983).

An EIS on the decision to restart the N-Reactor would answer, comprehensively and publicly, the hard question which DOE has so far avoided. That is, when the safety and environmental impacts of N-Reactor operation are balanced against the need for plutonium from the plant, is renovation and restart justified? Unless and until Congress and the American public have a full answer to this question we believe the N-Reactor should not be restarted.[1]

II. N-Reactor Restart

Based on available data, we believe DOE has a very difficult burden in proving that the N-Reactor should be restarted. Our views on the principal issues surrounding restart are outlined below.

---

[1] NRDC recognizes that consideration of the need for plutonium may necessitate a classified appendix to the EIS. However, such a document would, at a minimum, give our elected and appointed officials better information on which to determine the future of the N-Reactor. Just such a classified appendix was prepared in the L-Reactor EIS.

A. Reactor Safety

All agree that if the N-Reactor cannot operate safely it must not be restarted. Where there are differences, however, is over what constitutes a safe reactor. Our view is that the Nuclear Regulatory Commission's safety standards for commercial reactors provide the minimum acceptable level of safety for any power or production reactor in the U.S. If the N-Reactor, following renovation, cannot provide a level of safety equivalent to that required of commercial nuclear power plants, it should not be restarted.

If there was one message which came through loud and clear from the Roddis panel which investigated the N-Reactor last year, it was that the N-Reactor does not meet NRC safety standards. Chairman Roddis concluded, "that the overall risk of release of radioactivity [from N-Reactor] is significantly larger than from a commercial reactor." Moreover, Mr. Roddis found that even with the planned safety improvements at the N-Reactor the hazard to the general public form operation of the facility will still exceed that of a commercial facility.[2]

---

[2] One severe accident scenario identified by Chairman Roddis was a break in an embrittled process tube causing stress on adjacent tubes and this stress propagating throughout the reactor core. Chairman Roddis concluded that such a scenario made a Chernobyl-type accident "possible" at N-Reactor. Just last month DOE announced that it had discovered cracks in N-Reactor process tubes. DOE has agreed to inspect a larger number of process tubes than originally intended when the N-Reactor was shut down, however almost 85% of the tubes will still not be surveyed.

The N-Reactor's failure to meet NRC safety standards reflects the lack of a containment system found on virtually all U.S. commercial reactors including the Three Mile Island reactor. Such a system is designed to seal off the reactor so that radioactivity released from the core in an accident is not released to the environment. In contrast, the N-Reactor relies on a so-called confinement system which in an accident is intended to filter out most radioactive particulates. However, this filtration system, even if it functions properly, is not capable of preventing the escape of radioactive noble gases such as xenon and krypton. Moreover, if the filters are overwhelmed or disabled by smoke, steam, high temperature, or pressure they would also permit the release to the environment of large amounts of radioactive particulates.

Release of most of the noble gases and even a very small percentage of the radioactive particles and halogens could result, depending on meteorological conditions, in up to a few hundred deaths from acute radiation sickness and radiation-induced cancers, up to several tens of thousands of radiation injuries, and the contamination of hundreds of thousands of square miles of land and water in Washington, Oregon and Idaho. The financial loss from a major accident could involve billions of dollars.

Despite its indisputable safety advantages and a price tag of perhaps 10-20% of the cost of a new production reactor, DOE will not install a containment system at the N-Reactor as part of the planned renovations. Unless and until such a system is installed, the N-Reactor will not provide a level of safety equivalent to that of commercial nuclear power plants.

B. Emergency Planning

The impacts of a severe accident at the N-Reactor may be exacerbated by inadequate emergency planning. We have not analyzed emergency plans for the N-Reactor in detail, however we have considered similar plans for DOE reactors at the Savannah River Plant (SRP). A study commissioned by NRDC and the Energy Research Foundation concluded that people living sixty miles or more from the SRP reactors and in the plume of a severe reactor accident would run a significant risk of thyroid cancer and may have to leave their homes for up to thirty years. "Implications of Severe Reactor Accidents at the Savannah River Plant," Gordon R. Thompson, January 27, 1987. Despite this fact, DOE's emergency planning assumes little in the way of off-site consequences from reactor accidents at SRP. Under DOE's emergency plan at the SRP, for example, populations outside of two small areas less than 2 miles from the SRP boundary would not have to be given immediate warnings or be the subject of protective actions in the event of an accident. Final Environmental Impact Statement, L-Reactor Operation, SRP, Volume II, H-5 (1984). On-site DOE postulates that in a worst case accident there would be no deaths, and only 400 employees out of a total workforce of some 15,000 would receive radiation exposure, and that exposure would be below levels causing radiation sickness. Aiken Standard, August 26, 1986 at 1.

The differing conclusions reached by DOE and the NRDC-ERF study reflect disagreement over what constitutes a credible "worst-case" accident at SRP. The NRDC-ERF study assumes a substantial core melt and release of 50% of the radioactive iodine and cesium in the reactor core. This is similar to the spectrum of potential releases upon which the Nuclear Regulatory Commission emergency planning regulations are based for accidents at commercial nuclear reactors. 10 C.F.R. 100. DOE, on the other hand, assumes only a 3% core melt, resulting in a release to the environment of less than 1% of all radioisotopes in the reactor building atmosphere except noble gases and tritium. As a result, DOE's emergency planning at the Savannah River Plant encompasses a minuscule off-site population. Essentially, by assuming little in the way of off-site releases for a worst-case accident, DOE is able to minimize the need for off-site emergency planning.

C. Routine Environmental Impacts

On top of the risk of catastrophic accidents at the N-Reactor, exacerbated by inadequate emergency planning, must be added risks to human health and the environment from routine operation of the plant. The N-Reactor produces vast quantities of high- and low-level nuclear waste, non-radioactive chemical wastes, and mixtures of radioactive and non-radioactive wastes (mixed wastes). Almost 500,000 gallons of liquid high-level wastes have leaked into soil from deteriorating storage tanks. Large quantities of low-level wastes disposed of in unlined pits are leaking into the Columbia River. There are literally hundreds of hazardous and mixed waste disposal sites causing or threatening contamination of soil and ground water.

Adding insult to injury, the N-Reactor discharges 450 million gallons per day of hot water to the Columbia. Water temperatures as high as 136° F have been recorded. Concerns have been raised by federal and state agencies regarding the ecological impacts of these massive discharges particularly on young migratory salmon. Moreover, documents recently obtained under the Freedom of Information Act reveal that the N-Reactor has violated its Clean Water Act permit an average of 23 times per year for the past five years. Equally troubling, DOE seems to have reported fewer violations in its monthly discharge monitoring reports to EPA. Finally, DOE has failed to meet an important Clean Water Act permit condition requiring it to either bring N-Reactor thermal discharges into compliance with state standards or seek a variance under the Clean Water Act by June 30, 1985.

In view of these substantial violations of the Clean Water Act, we filed a Notice of Intent to sue DOE in June of this year. We are prepared to file suit at the end of the 60-day notice period to force full DOE compliance with the Clean Water Act prior to any restart of the N-Reactor.

D. The Need For Plutonium and Production Alternatives

The DOE has defended its decision to restart the N-Reactor, despite the reactor's significant safety and environmental impacts, citing the need for the plutonium. Our research, however, has shown that the plutonium which could be produced at the N-Reactor over the remaining years of the plant's useful life is not needed to meet DOE nuclear warhead production requirements. As an alternative, DOE could use plutonium in the current stockpile to meet production requirements.

We calculate in a recently published book that there are approximately 100 metric tons (i.e. 100,000 kilograms) of plutonium in the U.S. stockpile. Nuclear Weapons Databook, Vol. II, Ballinger (1987). Most of this material is contained in the approximately 25,000 warheads in the U.S. arsenal. This means that, on average, there are about four kilograms of plutonium in each warhead. When operating at full capacity the N-Reactor produces about 600 kilograms of plutonium each year, i.e. the equivalent of about 150 warheads, on average. During the Reagan Administration the U.S. has retired between 1500 and 2000 old warheads. The plutonium contained in these old warheads is recycled into approximately the same number of new warheads. Our message today is that by increasing the retirement of obsolete warheads by about 10% each year, i.e. 150 warheads, for the next few years we would obviate the need for the restart of the N-Reactor. Members of Congress have for years called on the

Department of Defense (DOD) to increase the rate of retirement of obsolete weapons. The DOD would be hardpressed to argue that the security of the U.S. would be threatened by an arsenal containing 24850 instead of 25000 warheads.

DOE may argue that the additional plutonium from the N-Reactor is needed for so-called "surge" capacity, i.e. to provide a cushion in the event of a drastic increase in Soviet production of nuclear weapons materials. However, DOE already has on hand a sizeable reserve -- several tons -- of plutonium for this purpose. In addition, there is an additional surplus of several tons of weapon-grade plutonium in the form of scrap. The available scrap is believed to exceed the total plutonium production that could be produced by the N-Reactor over its remaining lifetime were it restarted. In other words, by judiciously mining the plutonium scrap, the restart of the N-Reactor could be avoided even without accelerating retirement of obsolete warheads.[3]

The bottom line, then, is that the N-Reactor is not needed for plutonium production over the remaining years of its useful life. Existing plutonium in the U.S. stockpile is sufficient to insure U.S. national security.

---

[3] Moreover, the Senate Appropriations Committee recently revealed that the demand for plutonium is roughly in line with the rate at which the material is recovered from old weapons. Science Magazine, May 1, 1987 at 515. According to the Committee, DOE's production reactors, including the N Reactor, simply "are not the main source of material for weapons." Id.

E. Costs of Renovation and Limited Lifespan

DOE estimates that the five year renovation plan for the N-Reactor will cost as much as $200 million. Yet when completed the plant will still lack a containment system, the key ingredient for safe operation. Moreover, the renovations will be made to a reactor with an extremely limited useful life. The N-Reactor already exceeds its original design-life by five years. Chairman Roddis concluded that even with safety improvements the reactor should not be operated beyond the early 1990's. And DOE itself has admitted that the useful life of the N-Reactor does not extend beyond the mid-1990's. Hundreds of millions of dollars may therefore be spent on a reactor which may operate for only another three to seven years, and which still does not meet commercial safety standards.

F. Conclusion

The safety and environmental risks of the N-Reactor operation are substantial and exceed those of commercial nuclear power plants. The plutonium that would be produced by the plant during its limited remaining useful life is not necessary for national security. On balance, these facts raise serious questions about whether the N-Reactor should be restarted. The Senate Armed Services Committee recently concluded that the N-Reactor should be mothballed and restarted only in a national emergency. The Senate Energy and Natural Resources Committee should give serious consideration to this conclusion and the facts that support it.

III. Legislation

The health, safety and environmental problems at the DOE defense materials production facilities reflect a lack of outside oversight of DOE and contractor operations. For more than forty years DOE and its predecessor agencies have produced defense materials in an essentially unregulated manner. DOE is still the sole policeman of the safety of its nuclear materials production reactors and processing facilities and the disposal of most radioactive wastes. Unlike commercial nuclear reactors and waste disposal DOE is not subject to licensing and oversight by the Nuclear Regulatory Commission.

A number of pieces of legislation have been introduced to eliminate this unregulated state of affairs at the DOE facilities. They fall into two general categories. The first category, represented by S.1085 introduced by Senator John Glenn, would create a new independent safety board to oversee DOE facilities. The second category, represented by H.R. 783 introduced by Congressman Wyden (D-OR), would vest authority over DOE facilities in the NRC. We support the latter approach.

The Nuclear Safety Board, under S. 1085, would evaluate the implementation of health and safety standards at DOE facilities and investigate all "events" which are defined in S. 1085 as actions or failures to act which could have a potentially adverse effect on public health and safety. Although a step in the right direction, the Nuclear Safety Board created under S. 1085 is inadequate to address the need for outside oversight of DOE facilities. Under S. 1085, DOE would continue to operate its facilities under the authority of its internal Orders subject only to occasional reviews, recommendations and reports by the Board. DOE would not be subject to regulations developed by an outside agency after opportunity for public comment. Moreover, states and citizens would have no formal legal mechanisms to have violations addressed by the Board. Nor would there be a cadre of independent inspectors to insure compliance with the regulations. This last point was raised by a former top nuclear engineer at the Savannah River Plant in a recent letter to the Committee about Title I. Mr. Fred Christensen stated:

> [W]e remain most concerned that the proposed Department of Energy Nuclear Safety Board appears to be without qualified, resident, on-site inspectors at reactor sites...[w]e feel that such a Board would be as blind as was the ACRS [Advisory Committee on Reactor Safeguard which oversaw DOE facilities under the old Atomic Energy Commission]....
>
> If reactor operators are not well trained, if safety systems do not function as intended, if industrial fires could disable the confinement system, who, pray tell, is going to identify and report these problems to the Board? Surely not local management that has condoned the problems for thirty years, surely not QA [Quality Assurance] groups that report to local management. Such problems may or may not exist, but pray tell, how will the Board know? And that is the problem:

> The Board cannot know without qualified independent eyes on the job.[*]

Any agency created to oversee DOE facilities must have authority to develop and administer a full regulatory program which includes formal regulations, independent on-site inspectors to oversee their implementation, and a mechanism for public intervention to assure that violations are addressed. Such an agency already exists in the Nuclear Regulatory Commission. In our view NRC should be given authority over DOE facilities. Under H.R. 783, any new DOE facility would be licensed and operated under the same safety standards as commercial nuclear power plants, although modifications of the standards may be necessary, on a case-by-case basis, to reflect the unique operations of some of the DOE facilities. Existing DOE facilities should also be held to commercial standards. Where an existing DOE plant or operation is unable to meet certain standards, NRC should develop a reasonable timetable for either bringing the unit into compliance or phasing it out.

We recognize the shortcomings of the current NRC. We are confident, however, that these problems can be corrected.

---

[*] By way of analogy, the National Transportation Safety Board (NTSB), upon which the Nuclear Safety Board is modeled, investigates and makes recommendations about transportation accidents. Day-to-day oversight of the airlines industry, however, is the role of the Federal Aviation Administration (FAA). The safety of U.S. air travel depends upon both of these functions. While the Nuclear Safety Board would function similarly to the NTSB, it would not have a comprehensive, day-to-day regulatory function akin to that of the FAA.

Overall we believe a reconstituted NRC, with its comprehensive regulatory structure and corps of inspectors, is superior to the Nuclear Safety Board, with its limited oversight function, lack of on-site inspectors and absence of a mechanism for formal public intervention.

Senator EVANS. On page 6 of your statement you say, "Our view is that the Nuclear Regulatory Commission's safety standards for commercial reactors provide the minimum acceptable level of safety for any power or production reactor in the United States." And you just reiterated that. I presume then that you advocate shutting down all of the military reactors in the country.

Dr. COCHRAN. I do not advocate doing that overnight. I mean, I think you——

Senator EVANS. Why not? You say the minimum standard——

Dr. COCHRAN. Well, because I agree with Mr. Roddis that ultimately you have to make a tradeoff between national security and public health and safety.

Senator EVANS. Well, then you cannot make a statement like made in—this statement is either an inaccurate statement or it is hortatory.

Dr. COCHRAN. Our statement with—I believe with respect to the Savannah River reactors, that like the N-reactor you cannot make a—you cannot conclude that you need to operate those reactors for plutonium production at this time, and that the tritium production is another matter. You have to replace the tritium so long as we rely on tritium in the stockpile.

Now, the appropriate mechanism for resolving these issues of the tradeoffs between the need and the safety is to do an environmental impact statement on the production complex and have full public participation in that problem, to the extent you can, limited by the classification problems, and resolve it in that legal framework.

Senator EVANS. I am trying to get at your statement. You know, this is part of what is submitted for the record. This is the record the committee has to work on, and I want to know whether you stand by what you submitted or whether you want to modify it.

On page 6 you say, "Our view is that the Nuclear Regulatory Commission's safety standards for commercial reactors provide the minimum acceptable level of safety for any power or production reactor in the United States." That is a pretty definitive statement.

Dr. COCHRAN. I stand by that. I would say——

Senator EVANS. Well, then you would want to shut down the reactors at Savannah River because they have no containment.

Dr. COCHRAN. No. I would say that if the President of the United States wants to override the safety standards for national security reasons, then he should have that authority or the Congress.

Senator EVANS. Do you want to add that to the statement then?

Dr. COCHRAN. Well, I think it is clear from my statements——

Senator EVANS. I do not think it is clear at all.

Mr. REICHER. And Senator, I think it is clear from the previous page that we have set up a balancing test.

Senator EVANS. Well, then why did you say what you said on page 6 because that shows no balancing test? That is a definitive statement. It is pretty clear, if I can read the English language, it says——

Mr. REICHER. That is right with respect to the issues of safety. And then you have to balance those issues of safety against the question of need as we state on page 5.

Senator EVANS. Let me get on to the——

Mr. REICHER. "So that if there is, in fact, a demonstrable need, which we submit there is not with respect to plutonium at N-reactor, then you shut the reactor down."

Senator EVANS. Let's get to the demonstrable need question.

Dr. Cochran, have you had access to classified briefings on plutonium or tritium needs and supply in the United States?

Dr. COCHRAN. No, sir.

Senator EVANS. When did you receive your physics degree?

Dr. COCHRAN. In 1967.

Senator EVANS. In 1967. Was that with a specialty in nuclear science?

Dr. COCHRAN. It was in nuclear physics, but it was—my Ph.D. dissertation was in high energy nuclear physics, bubble chamber experiments, which is not reactor operations.

Senator EVANS. Have you had experience since that would come closer to nuclear operation?

Dr. COCHRAN. Well, I feel like I am qualified to analyze the operations of—some of the operations of nuclear reactors. I might say, I took courses in nuclear reactor engineering as an undergraduate. I have worked at the Oak Ridge National Laboratory as an AEC health physics fellow. I was hired by Resources for the Future in 1971 to write a book on the effluents from the nuclear power industry. I spent two years studying the nuclear power industry and nuclear power reactors. I have written, co-authored, a book on the production reactors—the nuclear warhead production complex of the U.S.

With respect to the need issue, there are fairly straightforward ways you can calculate the plutonium or tritium output from a reactor if you know the energy output, thermal output, of the reactor and the type of reactor it is. You can calculate the plutonium output fairly accurately.

And those data are unclassified. The thermal energy output of all of the production reactors throughout their histories has been declassified, as is the case with the N-reactor.

So, there is really not a large uncertainty—certainly not a large uncertainty in the amount of weapon-grade plutonium in U.S. stockpile. I do not know the classified figure, but I would say that our estimates are fairly close and are based on the widely available unclassified material.

Senator EVANS. But your experience is as health fellow—this is post-graduate—as a health fellow and writing a book and then as a staff member of the NRDC?

Dr. COCHRAN. Among others. I was on the Energy Research Advisory Board, the senior advisory board—actually under—Mr. Roddis was chairman for part of that time—advising the Secretary of Energy on all matters related to civilian energy production.

I have had advisory roles at the Nuclear Regulatory Commission. I was the principal technical expert in NRDC intervention on the licensing of the liquid metal fast breeder reactor at Clinch River.

So, you know, I could go on. I have some experience in the nuclear field. Maybe I would be an embarrassment to some, but others think I have some competence.

Senator EVANS. Well, I wanted to set that record simply because it is such a contrast with the testimony of Dr. Roddis who has had

41 years in the field, who in answer to the question of need said that he was not prepared because he didn't have the information necessary to make that——

Dr. **Cochran**. Dr. Roddis has not analyzed the production end of the weapons program. I have spent the last 5 years analyzing that and wrote this book.

Senator **Evans**. But you have access to the use end.

Dr. **Cochran**. To the use end?

Senator **Evans**. Yes.

Dr. **Cochran**. Well, the use end is to—the plutonium, the tritium, the highly enriched uranium, the other materials are used in the manufacture of the nuclear weapons, which we have studied also.

Senator **Evans**. Do you have access to information on whether the particular characteristics of a specific nuclear weapon require more or less plutonium per unit of ultimate yield of the weapon?

Dr. **Cochran**. The design numbers for a specific weapon, the amount of plutonium, the amount of uranium, the amount of tritium in any particular weapon, are classified and I have no knowledge of that.

Senator **Evans**. So, you really cannot tell——

Dr. **Cochran**. No, that is not true. Slow down a little bit.

We do have information on the total size of the uranium stockpile in weapons and plutonium in weapons and much less accurately, the tritium in weapons. And we have a pretty good handle on the total number of weapons. So, our estimates are based on, so to speak, an average weapon.

Now, we also know, for example, that the trends and weapons builds over the—oh, since 1945 actually, which has been towards increasing the amount of plutonium per weapon on average, although some weapons contain no plutonium and some more. But the average plutonium content per weapon has gone up as a result of design trends towards higher yield to weight and higher yield to volume in terms of the specific weapons.

And for that reason, even though the stockpile has decreased from its peak in about 1965 or so—I have forgotten the exact date—by about—from 32,000 down to about 25,000, give or take a few thousand, the amount of plutonium in the weapons themselves has continued to rise. And it is for that reason that during that period the Savannah River plant continued to operate primarily in the plutonium production mode.

So, I guess I would urge you to read volume II of our Databook and perhaps even volume I, and get a feel for yourself of how much information one can draw on the unclassified literature in terms of the need for plutonium and the requirements.

Mr. **Reicher**. And I would add that a number of eminent physicists have also taken part in producing this book and in developing the information and some with equal or greater experience with nuclear power and nuclear weapons than Dr. Cochran. And it has been subject to peer review.

Senator **Evans**. But certainly not with access to classified material.

Dr. **Cochran**. No, no. Listen, I don't ask you to substitute my judgment for the Department of Energy's in every respect. I think there is a process that we can go through to get to the bottom of this, and that is the environmental impact statement process. And that statement would be prepared by the Department of Energy which has access to the information. The classified data would be put in a classified appendix. The public would comment on the unclassified portions of the document, and the Congress, including more interested members like yourself, would be able to read the entire document and come to your own conclusions.

I am just trying to present what I think the facts show on the basis of the unclassified information that is available today.

Mr. REICHER. And I would add that it was a very positive sort of process that the DOE went through with the L-reactor that resulted in some very substantial and important environmental and safety modifications to the plant as a result of that environmental impact statement. And so, this is not a paper exercise.

Senator EVANS. My concern is not so much about whether or not an environmental impact statement is required, which may very well be a useful thing. It is frankly more on some of the definitive statements that you make in your paper, which is what we have to go on, that I do not think are really justified by the——

Dr. COCHRAN. Let's go through them one at a time because I think I can defend them.

Senator EVANS. Well, "Our research, however, has shown that the plutonium which could be produced at the N-reactor over the remaining last years of the plant's useful life is not needed to meet the DOE nuclear warhead production requirements."

Dr. COCHRAN. Senator, let's take that statement. We know that the N-reactor operating in the weapon-grade mode produces about 600 kilograms of plutonium per year. It is operating at about 50 percent capacity, which is sort of a historical number—a capacity factor based on its history.

Now, we know that the stockpile of plutonium in the weapons program is on the order of 100 tons, and there are about 25,000 weapons, which means on average there are about 4 kilograms of plutonium in a weapon. So, on average——

Senator EVANS. I have seen—you do not have to go through all of that. If you are going to go through what is in the paper, it gets down to——

Dr. COCHRAN. I mean, you are——

Senator EVANS.—the 24,850 instead of 25,000 warheads.

Dr. COCHRAN. Well, I am saying that most of the plutonium for the new builds comes from retirements, and you can accelerate retirements. And if you look at the congressional hearings, you see the Congress admonishing DOD to get on top of the retirements because there are obsolete weapons out there that could be retired faster than they are being retired.

Senator EVANS. Are you familiar with or do you know the geometry of new weapons and the amount of yield for those new weapons—or the amount of plutonium required per unit of yield and whether that is up or down or the same for the obsolete weapons they replace?

Dr. COCHRAN. Oh, it's up. As I indicated before, the trend is towards increase yield to weight and yield to volume. And therefore, typically a new weapon requires more plutonium than old weapons.

Senator **Evans**. I am not talking about increased yield. I am talking about per unit of yield.

Dr. **Cochran**. The efficiency of weapons in yield per unit mass of fissile material has increased over the years. I mean, the weapons labs are doing their homework, and weapons today are of more efficient design than those produced in the early years.

Senator **Evans**. Do you know whether that is true depending on the geometry of the weapon or what kind of a weapon you have or for what purpose it is going to be used?

Dr. **Cochran**. I know a fair amount about the subject. I am not just qualified, for example, as Dr. Wade and others who have intimate knowledge of and have built their careers around in the weapons business. And I have direct knowledge about the design and the weapons. I mean, there are some things that designers can tell you that I could not begin to tell you. There are some things that I can tell you on the basis of my knowledge as a physicist and the publicly available information. And I think our testimony does not go beyond that capability.

Senator **Evans**. Thank you very much. Thank you both for coming.

Mr. **Reicher**. Thank you, Senator.

Senator **Evans**. The meeting is adjourned.

[Whereupon, at 1:15 p.m., the hearing was adjourned.]

APPENDIXES

APPENDIX I

Responses to Additional Committee Questions

Department of Energy
Washington, DC 20585

October 22, 1987

Honorable Wendell H. Ford
Chairman
Subcommittee on Energy Research and Development
Committee on Energy and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

On July 17, 1987, Mary L. Walker, Assistant Secretary for Environment, Safety, and Health, appeared before the Subcommittee on Energy Research and Development of the Committee on Energy and Natural Resources to discuss the public health and safety aspects of the operation of the Department's facilities for special nuclear materials production.

Following that hearing, you submitted written questions for our response to supplement the record. Enclosed are the answers to those questions.

If you have any questions, please have your staff call Michael Gilmore on 586-4277. He will be happy to assist.

Sincerely,

G. Thomas Todd
for Robert G. Rabben
Assistant General Counsel
for Legislation

Enclosures

Celebrating the U.S. Constitution Bicentennial — 1787-1987

POST-HEARING QUESTIONS AND ANSWERS

RELATING TO THE

JULY 17, 1987, HEARING

OF

MARY L. WALKER
ASSISTANT SECRETARY
FOR
ENVIRONMENT, SAFETY AND HEALTH

Before The

SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES

FOLLOWUP QUESTIONS FROM SENATOR JOHNSTON

Question: Why shouldn't DOE operations just be made subject to regulations by the Nuclear Regulatory Commission?

Answer: Historically, the differences in mission (power generation vs. defense and research), ownership and enforcement (commercial vs. government), and operations (basic reactor design vs. one-of-a-kind production and research facilities) made direct use of NRC regulations infeasible. Further, the focus of NRC regulation was purposefully limited to commercial reactors as there was no question as to the government's ability to set and enforce standards at government-owned reactors.

The Department's stated policy is to ensure that a level of safety assurance is achieved at DOE facilities comparable to that afforded by NRC regulation at commercial facilities. Because of the special nature of many of the Department's operations and facilities, the applicability of NRC requirements and guides need to be assessed before actions can be taken at DOE sites. As a complement to this prescribed assessment, a rigorous facility appraisal program is also necessary to assure that the policy of comparability has been achieved to the extent necessary. Recent reviews by DOE and outside experts have indicated that a number of existing DOE research and nuclear defense material production facilities, due to age, differences in design and limited prospects for backfit, cannot meet all current NRC standards applicable to new reactors, although they can be operated in an acceptably safe manner.

All recently constructed DOE nuclear research facilities, with the most notable example being the Fast Flux Test Reactor at Hanford, Washington, have been designed to satisfy all applicable NRC facility and operational requirements. Future DOE research and production nuclear facilities will be designed and operated such that the level of safety assurance will be fully comparable to that required by NRC regulation for commercial activities.

The Department has been examining alternative mechanisms for outside nuclear safety oversight, NRC regulation included. Although DOE believes that an advisory Nuclear Safety Board represents the most effective approach to outside oversight of DOE's nuclear operations at this time, we believe this issue should be revisited via a legislative sunset provision once experience has been gained with the Board and with the ongoing DOE program of facility enhancement and replacement.

FOLLOWUP QUESTIONS FROM SENATOR JOHNSTON

Question: What are the differences in the regulatory authority that would be feasible for:

- DOE's defense materials production facilities?
- R&D facilities?
- Naval reactor program?
- Waste management?
- Other DOE programs?

Answer: The differences in regulatory authority would be primarily in the nature of the regulatory program for both defense materials production and waste facilities and for R&D facilities. Regulation would need to be flexible enough so that it could meet the diverse needs of both types of activities. The types and detail of the application of industry standards would have to be tailored to the various operations based on the different technical issues and risks presented by the facilities. The regulatory authority would also need to acquire expertise in many diverse areas in order to be effective. In addition, the regulation of defense related activities would need to provide assurance that the Department can effectively accomplish its national security mission and not expand access to national security information unnecessarily.

Regulatory authority for civilian waste management programs is covered by the Nuclear Waste Policy Act of 1982. The Naval Reactor Program is prescribed in Executive Order 12344 and Section 1634 of Public Law 98-525. Changes in the regulatory authority over these latter two programs are not envisioned by the Department or legislation currently being proposed.

FOLLOWUP QUESTIONS FROM SENATOR JOHNSTON

Question: What is the difference between oversight by an independent safety board and regulation by a commission like the NRC?

Answer: In evaluating alternative oversight approaches, there are several key considerations that the Department believes must be evaluated. These considerations are:

- Preserving the Secretary's ability to balance conflicting needs in operating the Department's facilities;
- Maintaining the momentum achieved under the Secretary's initiatives and institutionalizing the organization and programmatic improvements he has established;
- Preserving line management responsibility for safety and environmental compliance; and
- Assuring the independence, accountability, and practicality of an outside oversight function.

While these considerations have led us to conclude that an advisory body would be far preferable to a regulatory body, these same considerations are useful in comparing differences between an independent safety board and regulation by a commission like the NRC.

An independent safety board would better preserve the ability of the Department to effectively accomplish its national security and energy research missions. Although the board proposed in Senator Glenn's bill has accountability provisions which limit the Secretary's perogative, it could be tailored to meet DOE's diverse needs in both defense related facilities and research and development and, therefore, would be more likely to maintain a commitment to DOE's unique operation and national security mission. Establishment of a safety board would also retain the most positive elements of the current DOE system and assure strict accountability by DOE and its operating contractor for the safety of its activities.

Regulation by a commission like the NRC would also provide for a credible outside review of DOE but may not be as responsive to DOE's mission and needs and could impact NRC's primary mission of regulating commercial nuclear power plants. There would probably be a greater tendency to rely on NRC to determine safety adequacy and, thus, not preserve DOE's accountability for safety. Since both the NRC and DOE utilize the same group of experts (i.e., DOE's contractor and laboratory organization) for safety research and safety reviews, regulation by NRC would pose a conflict of interest for most DOE laboratories.

In summary, while the above key considerations have led us to conclude that an advisory board would be preferable to a regulatory body, an independent safety board dedicated to DOE oversight would better serve to strengthen the Department's existing safety program and provide for credible outside oversight.

FOLLOWUP QUESTIONS FROM SENATOR JOHNSTON

Question:	What are the trade-offs in terms of applying these concepts to DOE's defense programs?
Answer:	The trade-offs would be that NRC oversight of DOE's defense programs would facilitate comparability with the private sector, but the regulatory burden, complexity and the costs of implementation would increase significantly. Alternatively, if there were oversight by an independent safety board, the public involvement provided and prompt and decisive actions required by the Secretary of DOE would achieve enhanced safety in a more effective manner.

FOLLOWUP QUESTIONS FROM SENATOR JOHNSTON

Question: What role should public participation have in the oversight or regulation of DOE's defense program? Shouldn't an entity that is seeking credibility with the public respond to the public through a mechanism like public participation?

Answer: Public participation is viewed as an integral aspect of any outside oversight or regulation of DOE's defense program. Although security considerations will impose some restrictions, much can be accomplished through regular dissemination of information concerning the status of safety issues being addressed and opportunities for public input, e.g., through formal comment periods, and public meetings or hearings, as necessary, on recommendations made by any outside overseer, as well as the Department's response to the recommendations. The Department believes that an open oversight process, in which the public has a routine opportunity for viewpoints to be heard and addressed, is essential to assuring both the credibility and accountability of all parties in the safety oversight process.

FOLLOWUP QUESTIONS FROM SENATOR JOHNSTON

Question:	How should the oversight or regulation of DOE's defense programs be set up in the Federal Government? In DOE? Independent entirety? Within some other Federal agency? What are the pros and cons of each arrangement?

Answer: The responsibility for oversight and regulation of the activities and facilities of DOE's defense programs in the Federal Government should be vested with the Department of Energy, as it is now. This arrangement permits the vital national security missions accomplished by these programs to be overviewed by the Secretary, who is both responsible for accomplishing these missions and assuring that it is done in an acceptably safe and environmentally sound manner.

The Department is already regulated by the Environmental Protection Agency and its authorized states, and has signed Federal Facility Compliance Agreements with EPA as part of negotiated resolutions to outstanding compliance issues.

In occupational safety and health, the Department has established an oversight program based on standards and inspection programs of the Occupational Safety and Health Administration (OSHA). From a performance standpoint, this program has been effective, with the implementation of comprehensive inspection programs and injury statistics which compare favorably with similar private industry. From the standpoint of comparability, criticism has been raised over the independence of such oversight and the ease to which the National Institutes of Occupational Safety and Health has access to

DOE contractor employee health and safety data under this arrangement. The Department is currently taking actions to facilitate such access.

For nuclear safety, the Department is self-regulatory, basing its oversight program on national and international standards, and as a matter of stated policy, comparability with the safety assurance and oversight provided licensed commercial nuclear facilities. This institutional arrangement assures that national security interests and perogatives can be appropriately balanced by the Secretary of Energy, who has the statutory authority to exercise these missions, and balance their accomplishment with other considerations, including environment, safety and health. The imposition of outside regulatory or regulatory-like oversight would hamper the accomplishment of these missions by limiting the Secretary's authority and perogatives with respect to ES&H. However, an independent Nuclear Safety Board within the Federal Government advising the Secretary on nuclear safety issues and events would serve to strengthen the existing internal nuclear safety oversight system by providing a source of fully independent review and expertise and assuring accountability to needed safety improvements while preserving these authorities and perogatives.

Within DOE, the oversight of defense facilities is the responsibility of the line program, in this case Defense Programs, with independent environment, safety and health oversight provided by the Assistant Secretary of Environment, Safety and Health

(ASEH). This arrangement can be effective if ASEH is sufficiently independent and strong, one of the objectives of the Secretary's ES&H initiatives. Outside oversight would serve to provide additional independent overview to assure that internal oversight functions as intended. The detriment is that the effectiveness of the internal oversight system currently bears on management support of the independent ES&H function and effective line program administration of its safety responsibility, for which outside oversight would provide additional institutional assurance.

Oversight provided by an independent organization, such as a new non-Federal agency or new advisory board would be effective if it were properly constituted and was advisory in nature. The ACRS is a Congressionally legislated oversight body reporting to the NRC Commissioners. As Under Secretary Salgado testified on June 17, 1987, before the Senate Committee on Governmental Affairs, the Department believes such an approach is a viable option for consideration. Detriments that would need to be addressed are providing for a sufficient degree of DOE accountability to Board recommendations and providing it sufficient authority to overview facilities and investigate events.

Oversight provided by another Federal Agency, such as the Nuclear Regulatory Commission (NRC), would not be advisory and therefore would present the concerns already stated. It would not now be practical to expand to NRC's mission to overview DOE nuclear facilities. This is not to say, however, that organizational and functional changes at both the NRC and DOE over time would not eventually make such oversight acceptable, if the Department's national security mission could be safeguarded.

FOLLOWUP QUESTIONS FROM SENATOR JOHNSTON

Question: What is the role of inspection in oversight or regulation of DOE's defense programs? How should the overseer or regulator find out what is going on? Who should employ the inspections? Do we need on-site inspectors?

Answer: The role of inspection in oversight is to provide independent assurance that DOE operations are being conducted in accordance with Departmental policies. Currently, DOE operations are inspected and regulated by the various operations and line program offices, with independent oversight provided by ES&H personnel from Headquarters.

FOLLOWUP QUESTIONS FROM SENATOR JOHNSTON

Question:	Who should do the analysis of the information that does become available?
Answer:	Outside the Department's own review and action, an independent entity should analyze the information, and ultimately provide recommendations to the Secretary of Energy for action. The staff of the Office of Environment, Safety and Health would be expected to perform much of this analysis, with the assistance of consultants who have expertise in specialized areas of nuclear technology.

FOLLOWUP QUESTIONS FROM SENATOR JOHNSTON

Question: How should an oversight or regulatory program handle secrecy and the requirements of national security consistent with the public's need to know that the facilities are being operated safely?

Answer: The oversight/regulatory program must be in conformance with applicable National Security and security classification requirements. However, much can be handled on an unclassified basis and the oversight activity would have full access to information, classified or unclassified.

FOLLOWUP QUESTIONS FROM SENATOR JOHNSTON

Question:	Does the recent decision to subject DOE facilities to regulation by the Environmental Protection Agency under the Resource Recovery and Conservation Act mean that environmental regulation of DOE defense activities will be adequately regulated provided the necessary compliance agreements can be achieved?
Answer:	The recent Department of Energy (DOE) rulemaking regarding radioactive mixed wastes clarifies the applicable authorities for regulation of these wastes. DOE's May 1, 1987, rule provides for joint regulation by the DOE and the Environmental Protection Agency (EPA) or appropriately authorized states. The hazardous constituents of radioactive mixed waste are subject to regulation under the Resource Conservation and Recovery Act (RCRA) and the radioactive constituents are subject to regulation under the Atomic Energy Act (AEA). The DOE is actively working with EPA to implement the radioactive mixed waste rule and to develop compliance agreements where appropriate.

The DOE must comply with all applicable environmental laws, standards, and regulations, in addition to the RCRA. The DOE's Environmental Policy Statement issued in January 1986, clearly states that it is DOE's policy to conduct the Department's operations in compliance with the letter and spirit of applicable environmental statutes, regulations and standards. It is the broad framework of all environmental legislation that provides for adequate regulation of DOE defense facilities. DOE is actively implementing Secretary Herrington's Policy Statement and is seeking to achieve compliance with all applicable environmental requirements.

This effort includes the execution of compliance agreements with Federal and state regulatory agencies to demonstrate DOE's commitment to satisfy all applicable environmental regulatory requirements.

FOLLOWUP QUESTIONS FROM SENATOR FORD

1. N-Reactor

Question:	Why does DOE think that the N Reactor should be restarted when members of your review panel recommended that it be shut down permanently?
Answer:	Two members of a review panel recommended that the N Reactor not resume operations, but only if the reactor was not needed for national defense purposes. Subsequently, the Secretary of Energy has determined that there is a critical need for the N Reactor, which produces one third of this nation's plutonium.

Even the two reviewers who recommended discontinuing operation if the Plant was not needed for defense purposes proposed recommendations to enhance the safety of the N Reactor if operations were continued. Accordingly, out of an abundance of caution, DOE began implementation of N Reactor safety enhancements during January 1987 when the Plant was scheduled for regular maintenance and refueling.

The N Reactor will resume operations only after a careful review of the activities that have been initiated to implement the recommendations made by DOE consultants, and others, to enhance its safety. These steps will assure that the reactor poses no undue risk to the public.

FOLLOWUP QUESTIONS FROM SENATOR FORD

Question: How did the N Reactor come to be in such "sorry shape"?

Answer: The Department disagrees with the characterization of N Reactor stated in this question. The N Reactor is beginning to approach the end of its design life, which means that issues associated with life limiting conditions have been very visible and must be resolved. Moreover, in some respects, DOE has probably allowed the facilities to operate with fewer upgrades that would have been required of a comparable licensed facility. Observations about these conditions obviously have been a cause for concern, but the Department will not knowingly allow operation of any reactor that poses any undue risk to the public.

FOLLOWUP QUESTIONS FROM SENATOR FORD

Question: Was there no mechanism to identify needed improvements and make them? Isn't this what would happen in the case of a commercial reactor?

Answer: Mechanisms were in place to identify needed improvements and, as noted above, many safety enhancements were made. The Secretary took the initiative to establish and fund a strong, independent organization with adequate personnel to be an advocate and to assure him that safety requirements were being identified and properly implemented. The independent reviews that were performed at the request of the Secretary have resulted in new actions. Mechanisms to strengthen the process for making needed improvements are being put in place.

FOLLOWUP QUESTIONS FROM SENATOR FORD

Question: What is the trade-off in safety in restarting the reactor?

Many of the safety enhancement activities that will be performed prior to restart focused upon improving procedures, providing additional training, improving housekeeping and increasing the management emphasis on safety. In addition, hardware or equipment changes are underway and will either be implemented before restart or shortly thereafter. For this reason, the additional gains from delaying restart are marginal, and outweighed by the benefits from a resumption in operation as soon as the procedural and administrative improvements are in place, and the pre-established criteria for restart have been met.

FOLLOWUP QUESTIONS FROM SENATOR FORD

Question:	Would the restarted reactor meet safety standards equivalent to those that apply to the commercial reactors? If not, why not?
Answer:	No. The N Reactor does not meet some of the requirements of the general design criteria established by Appendix A to 10 CFR Part 50 which are applicable to new licensed nuclear power plants. However, a number of these criteria do not apply to N Reactor since they were developed for standard commercial BWR and PWR reactors and not for a production reactor. Nevertheless, the Department has considered these standards as useful guidelines in implementing its safety enhancement program for N Reactor.

FOLLOWUP QUESTIONS FROM SENATOR FORD

Question: Didn't the Roddis report identify an accident scenario (break in embrittled process tubes causing breaks in adjacent tubes) that could lead to a "Chernobyl-type" accident at the N Reactor?

Answer: Based on the detailed analyses and testing described below and the N Reactor negative void coefficient, pressure tube rupture at N Reactor will not cause a Chernobyl-type accident.

The Roddis report recommended further analysis on the effect of a longitudinal split in a process tube. Considerable study was given to propagation of a tube failure to adjacent tubes during N Reactor design and the potential for process (pressure) tube breaks was recognized and considered in its design in the early 1960s.

Since that time, there have been several additional analyses of the possibility of pressure tube rupture propagation. For at least the last 13 years the pressure tubes have been examined periodically under a documented Surveillance Program. As a result of planned improvement to this program, more analyses and inspections of the pressure tubes have been performed and plans have been made for replacement of any tubes of questionable quality.

Two pressure tube safety programs are now underway. First, a Surveillance Program consisting of eddy current and ultrasonic non-destructive testing and measurement of the current profile and ovality of pressure tubes has been implemented. This program provides information that is used to monitor the mechanical conditions and geometry of the tubes. Second, a Characterization Program has been implemented in which tubes are removed from the reactor and examined destructively and nondestructively to verify current pressure tube integrity and to predict future performance. Further, the Accelerated Safety Enhancement Program, instituted during the current maintenance and refueling outage, has a set of specific tasks directed at updating and refining previous analyses of the pressure tube rupture scenario, as recommended by the Roddis panel.

FOLLOWUP QUESTIONS FROM SENATOR FORD

Question: And haven't you recently found cracks in these tubes?

Answer: As a result of the Surveillance Program described above, which was initiated to identify pressure tubes with imperfections, ten out of 152 tubes inspected were found to have either surface flaws, surface abrasions, or subsurface flaw indications were identified at the N Reactor. Six tubes have been selected for removal from the reactor for destructive (postirradiation) examination under the current Characterization Program. They will then be replaced. One tube was found to have a longitudinal defect when it was destructively examined in April of 1987.

However, to date, no flaw has been found that does not meet ASME Section XI safety factor guidance although tube 1173 had a crack that, as a matter of prudence, would have led to its removal. No breaches of any pressure tubes have been experienced in the operating lifetime of the reactor. In addition, the pressure tube Surveillance and Characterization Programs will be ongoing safety measures designed to monitor, analyze, and verify that there is adequate integrity of the pressure tubes. Any issues on pressure tube integrity will be resolved before startup.

FOLLOWUP QUESTIONS FROM SENATOR FORD

Question: Is the Roddis scenario a credible one? If not, why not?

Answer: The Roddis scenario is not credible given the original reactor design and analyses the current Surveillance and Characterization Programs and the negative void coefficient at N Reactor. Current analytical models of the accident scenario, which conservatively assume degraded physical properties for the pressure tubes, coolant tubes, and graphite blocks that comprise the core, indicate that any deflection experienced in a pressure tube should not cause rupture of the adjacent pressure tubes. There also is an ongoing analysis, testing, and surveillance program to ensure pressure tube integrity and ES&H intends to review these analyses, in detail, as part of the Safety Enhancement Program for the N Reactor.

FOLLOWUP QUESTIONS FROM SENATOR FORD

2. Institutional Arrangements

Question: Who has the primary responsibility for safety at facilities like the N Reactor?

Answer: Safety, of primary importance within DOE, is a line program responsibility. The Program Senior Official, the Assistant Secretary for Defense Programs, has primary responsibility for implementation of the Department's environment, safety and health program at N Reactor. Further, the Assistant Secretary for Environment, Safety and Health exercises independent oversight authority over all DOE facilities on safety issues.

FOLLOWUP QUESTIONS FROM SENATOR FORD

Question:	How do you achieve a balance between production needs and operational safety?
Answer:	As noted in Under Secretary Salgado's testimony, before the Senate Committee on Governmental Affairs, a proper balance between production needs and operational safety can be achieved by assuring that safety standards are clearly defined and enforced, and by providing the Secretary and Under Secretary credible sources of both internal and external independent safety advice. While the Department has striven in the past to strike an appropriate balance, Secretary Herrington has sought through his 1985 ES&H initiatives to provide added assurance that production needs would not take precedence over safety and environment. These initiatives included a strengthened internal ES&H organization and more stringent independent ES&H oversight. He has since advocated the establishment of an independent outside oversight body for nuclear safety to provide added assurance that he and future Secretaries of Energy would be able to make decisions regarding defense production and energy research, from the broadest perspective of safety requirements and accepted practice.

FOLLOWUP QUESTIONS FROM SENATOR FORD

Question: What authority does Ms. Walker have?

Answer: My concurrence is required for construction, initial operation of reactors and high and selected moderate hazard facilities, and initial operating authorizations or modifications involving unreviewed safety questions. Furthermore, I have the authority to curtail or suspend operations when a clear and present danger exists to workers or members of the public. Beyond these explicit authorities, I have a broad mandate for independent oversight which is spelled out in various DOE Orders, including those enumerated below:

- DOE 5480.1B, Environmental Protection, Safety, and Health Protection (ES&H) program for DOE operations
- DOE 5480.2, Hazardous and Radioactive Mixed Waste Management
- DOE 5480.3, Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes
- DOE 5480.4, ES&H Standards
- DOE 5480.5, Safety of Nuclear Facilities
- DOE 5480.6, Safety of Nuclear Facilities
- DOE 5480.7, Fire Protection
- DOE 5480.8, Contractor Occupational Medical Program
- DOE 5480.9, Construction Safety and Health Program
- DOE 5480.10, Industrial Hygiene Program
- DOE 5480.11, Requirements for Radiation Protection (under revision)
- DOE 5480.12, Prevention, Control and Abatement of Environmental Pollution
- DOE 5480.13, Aviation Safety

- DOE 5481.1B, Safety Analysis and Review System
- DOE 5482.1B, ES&H Appraisal Program
- DOE 5483.1B, Occupational Safety and Health Program for GOGO Facilities
- DOE 5484.1A, ES&H Information Reporting Requirements
- DOE 5000.3, Unusual Occurrence Reporting System
- DOE 5500.1A, Emergency Management System
- DOE 5500.3, Reactor and Nonreactor Nuclear Facility Emergency Planning, Preparedness and Response Program for DOE Operations
- DOE 5599,4, Public Affairs Policy and Planning Requirements for Emergencies
- DOE 5700.6B, Quality Assurance
- DOE 6430.1, General Design Criteria

FOLLOWUP QUESTIONS FROM SENATOR FORD

Question: What is the burden of proof to take action in the case of a suspected safety problem?

Answer: The "burden of proof" is the existence of potential safety concerns, issues, or problems as established by facility review, incidents, or other experience that raises a substantial question as to the ability to continue to operate with no undue risk to the public or workers. Depending on the urgency of the problem, changes in operations may be required immediately or evaluations may precede the determinations of the appropriate course of action. In past situations, e.g., the 50% total reduction of power at the Savannah River production reactors, the Department has acted promptly to reduce power while investigations were underway to provide assurance that an acceptable level of safety is being maintained. The basis for action in this case was a finding of the existence of a potential safety concern, as made by both DOE safety inspectors and outside expert panels.

FOLLOWUP QUESTIONS FROM SENATOR FORD

Question: What resources does Ms. Walker have to investigate operations? Independent onsite inspections?

Answer: Since the announcement of the Department's ES&H initiatives in 1985, the resources for the Office of Environment, Safety and Health have increased by over 60% from $38 million and 101 FTEs in FY 1985 to $65 million and 155 FTEs in FY 1987. The FY 1988 request of $70 million and 165 FTEs, if approved, would represent an increase of almost 85% since 1985.

FOLLOWUP QUESTIONS FROM SENATOR FORD

Question: What independent resources does she have to analyze information?

Answer: In addition to my staff at Headquarters, I utilize the National Laboratories, independent consultants, and private organizations.

FOLLOWUP QUESTIONS FROM SENATOR FORD

3. EIS at the N Reactor

Question:	Why has DOE decided not to prepare an Environmental Impact Statement for the restart of the N Reactor that covers the full range of alternatives (i.e., including permanent shutdown, use of retired warheads for needed plutonium)?
Answer:	The N Reactor is a currently operating reactor and DOE is not proposing any action to alter that status. The only action being proposed by DOE is to implement the Safety Enhancement Program (SEP). It is this proposal that triggered the preparation of the Environmental Impact Statement (EIS) and, therefore, the question of whether to implement the SEP and how, is the only appropriate scope of the EIS. This scoping determination was made following careful consideration of the public comments received in the EIS public scoping process, in accord with the Council on Environmental Quality National Environmental Policy Act regulations.

FOLLOWUP QUESTIONS FROM SENATOR FORD

Question: Didn't you lose a court suit in a similar situation involving the restart of the L Reactor at Savannah River? What's the difference at Hanford?

Answer: The case referenced is NRDC v. Vaughan, 566 F. Supp. 1472 (D.D.C. 1983). However, there are crucial differences between the L Reactor restart and continued operation of N Reactor.

In 1983, DOE proposed to restart the L Reactor at Savannah River Plant, after a 14 year outage. During that outage, the L Reactor contained no fuel in its reactor vessel. Furthermore, the environment in Steel Creek and its delta had partially recovered from the effects of previous thermal discharges.

N Reactor, however, is a currently operating reactor. DOE is not proposing any action to alter that status. The current outage is a phase in a continuous operation. The reactor still contains fuel, and will be ready to resume production shortly.

These conditions demonstrate that there is no change in the continuity (status quo) of N Reactor operations and thus clearly distinguishes it from L Reactor.

FOLLOWUP QUESTIONS FROM SENATOR FORD

4. Oversight and Regulation

Question:	Why shouldn't DOE operations just be made subject to regulation by the Nuclear Regulatory Commission?
Answer:	See response to question 1, page 1.

FOLLOWUP QUESTIONS FROM SENATOR FORD

Question:	What are the differences in the regulatory authority that would be feasible for DOE's defense materials production facilities? R&D facilities? Naval reactor program? Waste management?
Answer:	Refer to response to same question posed by Senator Johnston.

FOLLOWUP QUESTIONS FROM SENATOR FORD

Question: Do you intend to check all the tubes? If not, why not?

Answer: The pressure tube surveillance program, including tube removal for destructive examination, has been ongoing since 1966. In addition, as part of the Safety Enhancement Program, the Department of Energy has recently inspected 152 of the 1003 pressure tubes in N Reactor using nondestructive examination (NDE) techniques developed for N Reactor application. A combination of statistical and technical analyses, post irradiation metallurgical examinations, and additional NDE tests are being used in the assessment of the remaining 851 pressure tubes. The results to date confirm that the pressure tubes meet or exceed all criteria for continued operation. Should future NDE, destructive examination or analysis reveal additional concerns, they will be evaluated and resolved by the ongoing program.

FOLLOWUP QUESTIONS FROM SENATOR FORD

Question: Why should extraordinary measures be taken to keep this reactor operating for such a short time when its safety is subject to so much question and what is really needed anyway is a new reactor?

Answer: The safety enhancement activities currently underway, and the maintenance, restoration and upgrades required to support N Reactor for the remainder of its life are of a magnitude similar to that historically required to support continued reactor operation and are not considered extraordinary. Following the Chernobyl reactor accident, N Reactor received several intensive dependent safety reviews. These reviews have confirmed that a Chernobyl-type accident is either "impossible" or "not plausible" given the design difference of the two reactors and the additional operational safeguards that exist at N Reactor. The basic lessons learned from the Chernobyl accident relate to ensuring the safe design features and establishing and adhering to operating procedures.

To further increase the safety margins of future operations, N Reactor was placed in a stand down condition in January 1987 to refuel, conduct normal maintenance, install additional safety equipment and systems, and to enhance procedures and operator training. In August 1986, the Under Secretary of Energy requested that the National Academy of Sciences/National Academy of Engineering, as part of its review of the Department of Energy (DOE) production reactors, inform DOE of any issues deserving immediate action as soon as any were identified. None have been identified regarding N Reactor. With regard to a new reactor, it is pertinent that it will take up to 10 years, after the decision to build a totally new reactor, to obtain defense materials from that reactor. The N Reactor could provide a significant contribution to nuclear materials production during that interim.

FOLLOWUP QUESTIONS FROM SENATOR FORD

Question: How long would the Department of Energy intend to operate the reactor after restart? Would not a new production reactor be needed within five years in any event?

Answer: The life of N Reactor, without additional measures beyond normal maintenance, restoration, and upgrades, is expected to last at least until the mid 1990's. Even using the most expeditious option, a new production reactor could not be operational within five years. It is anticipated that up to 10 years will be needed to address all institutional issues, regulatory process concerns, design and construction matters, and operational checkout issues of a new production reactor. In addition, the need and timing for a new production reactor also depend on the power level and length of operational life remaining in the three Savannah River Plant reactors and the availability of N Reactor. For these reasons, while a new production reactor is needed, it is clear that N Reactor, if restarted, could contribute significantly to providing nuclear materials in the interim before operation of a new production reactor.

QUESTIONS FROM THE MINORITY

Question: What type of institutional structure would you favor to provide the kind of "independent oversight of DOE" that Secretary Herrington now supports? How would the public be assured that any recommendations made by this independent body were carried out by DOE? Who would have the final say in regulatory/safety/environmental matters, the independent body or DOE? How would compliance with regulations be enforced?

Answer: As cited in testimony, the Department believes an advisory oversight function, such as a Nuclear Safety Board, would provide the most effective oversight while preserving the Secretary's prerogatives to fulfill the Department's national security mission. Such a Board, consisting of safety experts and possessing a broad scope of oversight activities, would operate in an open and publicly accessible manner. Under this option, both the Board's recommendations and the Department's response would be published and available for comment. It would be incumbent upon the Secretary to respond to all Board recommendations, with a full explanation for those that would not be implemented. Accountability would be provided by the open nature of the process and Congressional oversight.

Compliance with environmental regulations are enforced by the Environmental Protection Agency and authorized states. For nuclear and occupational safety, the Department would enforce its own requirements, with independent oversight provided by both the Assistant Secretary for Environment, Safety and Health and the proposed outside oversight function.

QUESTIONS FROM THE MINORITY

Question:	Is there anything wrong with the approach taken in Senator Glenn's bill (S.1085) or the approach taken in Price-Anderson (S.748) with respect to independent oversight of DOE activities? Please provide to the committee a detailed critique of each of these bills (independent oversight provisions only).

S.1085

Answer: While we agree with many of the objectives of S.1085, the specific oversight system envisioned in Title I would not effectively achieve them and could severely hamper the Department's ability to perform its national security mission.

- Title I has the effect of creating an NRC analog for DOE oversight (i.e., three-member Nuclear Safety Board, binding recommendations, and staffed by the Advisory Committee on Reactor Safeguards (ACRS). In actuality it is not "advisory," as is ACRS for the NRC, but constitutes an additional layer of regulation. This approach may not be the most effective or flexible one available to accomplish the stated purpose.

- The provisions prescribing Secretarial response to the Board's recommendations are of concern from both a process and substance standpoint. It forces a regulatory role on what we believe is more properly an advisory function, without due consideration of other key bases for ES&H decisions, e.g., cost-benefit analyses.

- No mention is made of the continuing need for and utilization of the strong internal ES&H function. Elimination or diminution of ES&H program would not retain the positive gains made in DOE by Secretary Herrington.

- While direct reviews of DOE facilities is an important part of independent oversight, an annual review of all such facilities would likely be overwhelming for the Board that is envisioned. In the past, the ACRS has focused its oversight on selected nuclear facilities and safety policy issues of significance, leaving NRC staff the responsibility for routine oversight. DOE/EH should similarly fulfill that function.

- The scope of functions afforded the Board is confined to "events" and the implementation of DOE standards. The objectives of outside oversight may be better supported by an oversight body with a broader, more flexible charter, which can be exercised depending on the significance of the issue.

- Alternatives for nuclear safety oversight available to the Department fall into two categories:

  (1) those that accomplish change through solely outside regulation; and

  (2) those that accomplish change by strengthened internal and outside oversight and improved checks and balances.

We believe the other provisions of S.1085 can be satisfied either directly (e.g., NIOSH), or through existing oversight mechanisms.

- Regarding Title II, DOE believes the concerns over NIOSH having direct access to DOE worker health records can be satisfied without legislation. With respect to the broader issue of OSHA oversight, DOE notes that since its occupational safety performance is superior to comparable outside industry, we can see no advantage in extending OSHA regulation, given the additional layer of regulation this would represent, and recognizing the practical issues of Federal supremacy and limited OSHA resources.

- Title III: The Department believes that its recent final rule on mixed waste provides all the clarification necessary on RCRA's applicability to DOE radioactive wastes and therefore new legislation is not necessary. Moreover, Title III would alter the existing regulatory jurisdiction established by the AEA for controlling radiological hazards associated with source, special nuclear, and byproduct material. DOE is strongly opposed to any provisions that would alter existing responsibilities under the AEA and believes that any such alteration would be counterproductive to maximizing the protection of the public, workers, and the environment from both chemical and radiological hazards.

- Title IV: DOE does not disagree with the need to assure an independent review of its radiation epidemiology studies. Such reviews are already provided on an ad hoc basis. Any formal Advisory Board, however, will require clear operating guidelines and criteria, as well as involvement by knowledgeable safety personnel.

S.748 (Price Anderson)

S.748 provides for the establishment of an independent Inspector General for Nuclear Programs who would report directly to the Secretary and Congress. Under S.748, this Inspector General (IG) would:

- supervise, coordinate, and provide policy direction for auditing and investigative activities relating to ES&H of the Department's nuclear program activities;

- recommend policies for and conduct, supervise, or coordinate other DOE activities related to ES&H;

- recommend policies for and conduct relationships between DOE and other governmental and nongovernmental entities with respect to ES&H matters and rule violations; and

- o inform the Secretary and the Congress of ES&H problems or deficiencies, recommend corrective action, and report on the progress made in implementing corrective action.

(The Johnston-McClure bill also calls for Presidential appointment of a panel to make further recommendations to Congress for regulation and oversight of DOE nuclear activities, including alternative regulatory regimes.)

The provision in S.748 to establish something called a Nuclear Programs IG would involve supervising, coordinating and providing policy direction for audit and investigative activities relating to the promotion of health, safety and sound environmental management in the administration of nuclear energy. The thrust of this provision seems to be to ensure that nuclear program operations are being conducted safely, in an environmentally sound manner, and in accordance with applicable safety, health, and environmental laws.

This function is not at all that which would traditionally regarded as an IG function. Traditional audit and investigative organizations are not best suited to perform activities involving physical observations of highly technical facilities and operations. Second, enforcement-related responsibilities are usually placed with the program office or entity responsible for promulgating the rules and regulations governing the regulated activity. Enforcement functions are inherently a program management responsibility. To include, under the title IG, enforcement responsibilities may signal to management that its responsibility to maintain high quality assurance over program activities is in part deferred to the special IG. Accountability for programmatic success might, therefore, become diffused.

To address these issues, the following alternatives are possible for establishing a Nuclear Programs IG. These alternatives would meet Congressional concerns while avoiding the problems associated with multiple IGs in one agency:

o Rename the function to avoid the connotation that a new IG function is being created.

o Augment Agency management resources and capabilities with management task forces, or new non-IG elements.

o Negotiate a cooperative arrangement between Agency management and the existing IG to focus on a particular problem area (this approach was used successfully at DoD to focus on the spare parts problem).

o Assign a unit of inspectors and technical experts within the statutory IG if the work required to address specific Congressional concerns is not strictly audit or investigative in nature. An Assistant IG with such responsibilities would have the authority to conduct special reviews or other activities that differ from traditional audits and investigations.

- Mandate a division within the existing statutory Office of Inspector General that is devoted to audits and investigations of a particular program. (This option is not without peril since it reduces the flexibility of the IG to shift its resources to meet programmatic changes and needs.)

QUESTIONS FROM THE MINORITY

Question:	Who conducts your safety appraisals and safety analysis reviews?
Answer:	Our safety appraisals and safety analysis reviews are generally performed by teams of 10-20 experts. The team is headed by an experienced DOE manager.

QUESTIONS FROM THE MINORITY

Question: You say that additional management commitment and time are needed to upgrade DOE's safety and environmental performance. How much time do you think is required so as not to adversely impact national security functions of DOE?

Answer: A number of internal and external factors influence the Department of Energy's (DOE) schedule for upgrading its safety and environmental performance. While it is difficult to quantify exactly when safety and environmental matters will adversely impact national security functions, we believe that both safety and environmental matters can be accommodated without adverse impacts on national security. The Secretary of Energy's environmental policy statement commits the DOE to conduct its operations in a safe and environmentally sound manner and in compliance with the letter and spirit of applicable environmental statutes, regulations and standards. The Department recognizes that environmental and safety problems must be dealt with in a timely manner while the Department continues to conduct its national security functions.

Many of these problems are a result of past practices that, while acceptable when done, were not environmentally sound or are not acceptable by today's standards. The DOE Environmental Survey Program and the Technical Safety Appraisals Program (TSAs), both major initiatives of the Secretary of the DOE, are designed to identify environmental and safety problems and to prioritize DOE-wide corrective actions. The Survey activities, which began in June 1986 are expected to be completed in mid-Fiscal Year 1989.

The TSAs began in February 1986 and will require three years to complete.

Although both the Environmental Survey and TSAs are not yet completed, the Department has taken, and will continue to take, appropriate actions to address as many problems as possible as they are identified. For example, at the conclusion of each on-site Environmental Survey at a facility, problems that may be addressed within existing budgets and resources are identified and responded to in a timely manner. Where compliance related problems that are under the purview of state and Environmental Protection Agency (EPA) regulatory authorities exist, the Department is currently working closely with the states and EPA to develop action plans and compliance schedules, which are committed to through Federal Facilities Compliance Agreements and/or Consent Orders where appropriate.

In summary, the Department is taking actions to upgrade its environmental and safety performance. In addition, the Department's current approach of first systematically identifying and characterizing its environmental and safety problems followed by Department-wide prioritization and scheduling of corrective actions will enable DOE to upgrade its environmental and safety performance without adversely impacting its national security functions.

QUESTIONS FROM THE MINORITY

Question: If you determined that your existing facilities--many of which are very old--could not be satisfactorily upgraded in a cost-effective manner so as to meet today's standards, how much time would be required to build new facilities, so that these older facilities could be retired in an orderly manner?

Answer: As an illustrative example, the time required to obtain funding, do design work, do environmental analyses and construct a replacement production reactor is estimated to be 10 to 12 years.

QUESTIONS FROM THE MINORITY

Question: If you were required to do a comprehensive EIS on N Reactor prior to its restart, how much time might this take?

Answer: Assistant Secretary Walker's testimony mentioned 18 to 36 months for completion of such an EIS. This is the most optimistic DOE estimate for completion of the EIS on the N Reactor Safety Enhancement Program only. Any broader EIS on N Reactor operations would take much longer than that of the SEP EIS - anywhere from 6 to 18 months longer. Therefore, an appropriate estimate for completion of a broader N Reactor EIS would be 24 to 36 months. Of course, this estimate is dependent on defining the exact scope of a "comprehensive" N Reactor EIS.

QUESTIONS FROM THE MINORITY

Question: How does DOE plan to pay for upgrades/replacements/monitoring activities with respect to safety and environmental compliance? Will each DOE activity be "taxed," or will DOE set up a separate, dedicated account?

Answer: With respect to Defense Programs, small ES&H candidate projects for upgrades, modifications and replacements normally are funded by utilizing existing available resources based on consideration of priority and estimated cost. Congressional guidelines would also have to be considered. Funding for larger projects is requested through the congressional appropriation process as specific budget line items.

ES&H monitoring activities are part of the field operations' line responsibility. Funding for these types of activities are normally funded from field overhead accounts.

For remedial actions required by CERCLA and RCRA, a new line item, Environmental Restoration, has been established within the Defense Waste and Environmental Restoration program.

QUESTIONS FROM THE MINORITY

Question: What is the status of the NAS reviews of the N Reactor and the Savannah River reactors? Will their reports be filed in time to factor their findings into the FY 1989 budget cycle?

Answer: The National Research Council, the principal operating agency of the NAS and NAE, submitted the results of its review of DOE's proposed approach to hydrogen mitigation for the N Reactor on August 26, 1987. A more comprehensive report on the safety of all DOE Class A reactors is expected to be published in mid-to late October 1987. DOE does not anticipate receiving a draft report prior to this date.

The report will not be available until the 1989 budget submittals are effectively frozen, but it is possible that some adjustments can and will be made prior to submission of the President's budget to Congress.

POST HEARING QUESTIONS AND ANSWERS
RELATING TO THE
HEARING BEFORE THE
SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

JULY 17, 1987

Troy Wade
Principal Deputy Assistant Secretary for Defense Programs
U.S. Department of Energy

QUESTIONS FROM THE MINORITY

Question 1: In terms of meeting our materials production needs, and considering the uncertain future of the Savannah River reactors and the long lead time required to bring new production capacity on-line, how critical is restart of N-reactor?

Answer 1: N Reactor is a critical and unique facility in the Nation's defense program. Its operation is necessary to meet stockpile modernization initiatives as approved by the President in the current Nuclear Weapons Stockpile Memorandum.

QUESTIONS FROM THE MINORITY

Question 2: Most people relate N-reactor operations to plutonium production. If, however, our major vulnerabilities lie in the ability to meet tritium production requirements, then the question arises as to the capabilities for using the N-reactor to meet these tritium needs. Has DOE ever used N-reactor for production of tritium? Would it be technically feasible to dedicate this reactor to tritium production? Would this require a more extensive EIS prior to restart?

Answer 2: The capability of N Reactor to produce tritium was demonstrated in 1967 and 1968 under the Coproduct Demonstration Program during which about 1,600 fuel columns were prepared, irradiated, and processed to produce tritium.

The feasibility of potentially using N Reactor for long-term production of tritium has been thoroughly studied. All of these studies confirmed the technical feasibility of producing significant of tritium at N Reactor.

The Department of Energy has no plans to convert N Reactor to routine tritium production at this time and would follow the National Environmental Policy Act as part of the decision-making process if such a change was proposed.

QUESTIONS FROM THE MINORITY

Question 3: A lot of people claim that putting a large amount of money into N-reactor safety upgrades would be wasteful, since the reactor only has a few more years of operating lifetime left, due to graphite swelling limitations. (a) How much could its lifetime be extended if it operated in the future at 50% power, as opposed to 100% power? (b) How would operation at 50% power enhance safety?

Answer 3: The expected cost for all of the currently planned safety enhancements at N Reactor is less than $125 million. This expenditure will not only enhance the operational safety of the reactor, but will provide added assurance of meeting plutonium requirements into the mid-1990's. This expenditure is very cost-effective when compared to other alternatives for meeting near-term plutonium requirements.

Operating N Reactor at about half power could extend the expected lifetime from the mid-1990's to the turn of the century based on current projected life-limiting conditions. Operation in this mode is not, however, the most efficient or most effective use of resources.

Operating N Reactor at about 50 percent power would enhance safety because of the reduced amount of heat that would be generated during an accident condition (after a reactor shutdown). The heat generation rate after reactor shutdown influences the potential for fuel damage and release of fission products from the fuel in hypothetical events where it is assumed that safety systems fail to operate. However, proper operation of reactor safety features would preclude fuel damage whether operating at 50 percent or 100 percent power.

QUESTIONS FROM THE MINORITY

Question 4: Why hasn't DOE considered putting containment around the N-reactor or the Savannah River plants?

Answer 4: Public Law 99-661 required the Department of Energy (DOE) to prepare a report comparing the costs and safety effects of constructing containment systems on existing DOE production reactors with the cost and safety effects of constructing a new production reactor (NPR).

The above report has been completed and concludes that, based on the age of the production reactors, the estimated reduction in risk, and the expected cost of constructing containment systems for these reactors ($2 to $5 billion), the containment structures are not warranted, and the NPR option is more cost-effective.

QUESTIONS FROM THE MINORITY

Question 5: How far are the Savannah River reactors from population centers? If, for whatever reason, DOE were required to have emergency plans in place for a 10-mile-radius zone around the Savannah River plant, how many communities would this affect? How many offsite people? What kind of emergency planning is presently in place for these plants?

Answer 5: The Savannah River Plant (SRP) boundary is about 20 miles distant from both Aiken, South Carolina, and Augusta, Georgia, the principal population centers around the plant site. Within the plant boundary, the closest operating reactor is approximately 5 miles from the boundary. Thus, the two principal population centers are at least 25 miles from the nearest operating reactor.

In concert with the requirements of both the States of South Carolina and Georgia, the Department of Energy (DOE) has developed and implemented site specific emergency plans encompassing areas out to 10 miles from each SRP reactor (the "emergency planning" zone) and out to 50 miles from plant center (the "ingestion pathway" zone). Within the emergency planning zone, the level of preparedness existing today includes facilities for immediate notification of State and local officials, and plans and procedures for the protection of public health and safety up to and including shelter and evacuation of the affected public. The terms and conditions under which State and local officials are notified of emergencies are defined in written memoranda of understanding between DOE and the States of South Carolina and Georgia. In addition, there are emergency public information brochures developed cooperatively with State and local officials and disseminated to the population within the 10-mile emergency planning zone. A total of about 7,500 people reside within the collective emergency planning zones for all SRP operating reactors. There is only one incorporated community (Jackson, South Carolina) located within the emergency planning zones. This community has about 2,000 residents, who are included in the 7,500-person total above.

For the 50-mile ingestion pathway zone, the States have their own plans for the control of foodstuffs, livestock, and other agricultural products in the event of an SRP emergency.

The SRP emergency planning program has been tested and validated twice since 1984, once in November 1984, and once in March 1987.

QUESTIONS FROM THE MINORITY

Question 6: Why does DOE assume, as the "credible worst case" accident at Savannah River, a situation that results in only 3% core melt and a resulting release of only 1% of the radiation into the atmosphere, when most commercial power plant accidents assume much worse conditions? Does this have something to do with the reactor operating conditions and design margins?

Answer 6: For purposes of satisfying the reactor site criteria in Part 100 of the Title 10 Code of Federal Regulations, a distinction is made between credible (or possible) accidental events and incredible events. For commercial nuclear power reactors, the credible range of accidental events includes those capable of melting major portions of the reactor core basically because of the large amount of stored energy in the core due to the high operating temperature and pressure. In the event of a major disruption such as a severe loss-of-coolant accident, the sudden loss of pressure would cause all coolant in the reactor to flash into steam. The resulting loss of cooling capability could cause widespread core damage and release of fission products within the containment structure.

This severe an accident is not considered credible for the Savannah River reactors, which operate at low pressure and temperature. The core has correspondingly low stored energy relative to a commercial reactor, so that disruptive events causing depressurization cannot cause loss of all cooling capability and subsequent widespread melting. The "credible worse case" event that has been identified in the Safety Analysis Report for these reactors is one involving a misloading error. Such an accident could cause localized criticality in a limited region of the reactor and melting of no more than 3 percent of the core.

QUESTIONS FROM THE MINORITY

Question 7: Please comment on NRDC allegations that N-reactor continually violates Clean Water Act requirements with respect to cooling water thermal discharges into the Columbia River. Have there been any adverse effects on Columbia River Salmon runs?

Answer 7: Prior to 1985 the majority of the N Reactor National Pollutant Discharge Elimination System (NPDES) permit violations were related to the thermal discharge limits. Since then, the majority of violations have been related to pH control of water being returned to the river. During the past 2 years, only two violations have been thermal discharge violations. The pH violations were caused by inadvertent releases of excessive water treatment wastes to the river discharge line. The potential for this type of violation has been eliminated with the addition of a holding pond for pH neutralization prior to release to a ground discharge.

As part of its application for renewal of the NPDES permit in 1984, DOE submitted a Compliance Plan to resolve the thermal effluent violations. In July 1987, the State informed EPA that it could not approve the Compliance Plan and that a request for waiver under Section 316(a) of the CWA should be required. DOE has committed to preparing the 316(a) variance request.

Other improvements, such as the addition of raw water systems to the 36-inch Raw Water Return (RWR) line to the river, have significantly reduced the potential of future NPDES temperature permit violations.

Studies conducted to date have shown that N Reactor thermal discharges have had no adverse effects on the Columbia River Salmon runs.

QUESTIONS FROM THE MINORITY

Question 8: NRDC claims that we could meet our plutonium requirements merely by retiring old warheads at a slightly accelerated rate (10% higher than current rate). (a) Would this compromise national security or treaty negotiations interests? (b) Would a 10% acceleration of retirements really fill the gap of N-reactor retirement? (c) In recycling warheads don't we lose a certain percentage of the plutonium in the process?

Answer 8: We cannot "merely" retire warheads at a slightly accelerated rate. The determination of our nuclear weapons stockpile and its force structure is based upon requirements to protect our national security. Every nuclear weapon built and maintained in the stockpile has been determined necessary for national security based on the Presidentially approved Nuclear Weapons Stockpile Memorandum. Potential changes to the nuclear stockpile and its effect upon national security and treaty negotiations cannot be unilaterally assessed by DOE.

Reductions to the plutonium inventory occurs with the processing of plutonium in maufacturing, retirement, and recovery operations. Losses to waste streams from plutonium recovery operations are a few percent of the materials processed. Additionally, due to processing capacity limitations, there are additional losses in useable plutonium inventories due to delays in the ability to process all of the recoverable plutonium in a rapid manner. These reductions will ultimately be recovered; however, a significant time-lag can develop.

QUESTIONS FROM THE MINORITY

Question 9: The NRDC claims that mining of plutonium scrap metal would more than offset the loss of N-reactor production capacity. But doesn't DOE already mine this plutonium scrap? How much plutonium is obtained by mining this scrap, in terms of relative quantities, compared to N-reactor output? Could DOE enhance its scrap mining capabilities to meet or exceed the annual output of N-reactor? At what cost? In what time frame?

Answer 9: The Department of Energy (DOE) already recovers plutonium scrap generated in the nuclear materials complex and is considering "enhancing" or accelerating this scrap recovery process. However, the additional increase in plutonium availability from this program would be but a small fraction of that already being recovered. The upper recovery limit is dependent on processing facility availability and not on the cost. Initiation of an accelerated scrap program in FY 1988 would make additional recovered plutonium available to the complex beginning in the early 1990's.

QUESTIONS FROM THE MINORITY

Question 10:	Can the Department of Energy say at this point that the N-Reactor production capability is not necessary for national security?
Answer:	In announcing the decision in December 1986 to place the N Reactor in a stand-down condition to complete an Accelerated Safety Enhancement Program, the Under Secretary of Energy stated that the operation of N Reactor was essential to meet national security objectives. There have been no events which would modify that statement. In fact, due to the current power level restrictions placed on the Savannah River production reactors, the Under Secretary's statement has been reinforced.

POST-HEARING QUESTIONS AND ANSWERS

ENVIRONMENTAL PROTECTION AGENCY

July 17, 1987

From Senator Johnston

Question 1: It appears from your testimony, and the appendix to your testimony, that DOE is making progress in addressing the environmental issues at its facilities and in working with EPA to achieve compliance with applicable regulations. Is that an accurate statement?

Answer: DOE is making progress toward bringing its facilities into compliance with hazardous waste regulations. For example, the July 1986 Federal facility agreement for the Rocky Flats plant in Colorado established commitments by DOE to characterize hazardous and radioactive mixed waste sites and to undertake necessary remedial actions for these sites. The successful negotiations for a Consent Order and Compliance Agreement for the Idaho National Engineering Laboratory (INEL) near Idaho Falls also demonstrates DOE's commitment to addressing environmental problems at its facilities. The Agreement outlines corrective actions to be taken where waste facilities are releasing contaminants into the environment, and includes enforceable schedules to achieve and maintain compliance. In a July 20, 1987 letter to Assistant Administrator, J. Winston Porter, DOE Assistant Secretary Mary Walker underscored DOE's desire to enter into similar agreements for other facilities using INEL as a model, including the enforceability provisions.

From Senator Johnston

Question 2: Do you believe that the condition of DOE facilities, from an environmental standpoint, is worse than other federal facilities? If so, what do you believe is the root cause of this?

Answer: DOE facilities present special problems of waste management compliance which are generally not issues at other federal facilities. The size and diversity of DOE facilities complicates efforts to bring them into compliance. DOE's hazardous waste management activities involve over 250 RCRA permitted or interim status TSD facilities, and approximately 20 million tons of hazardous and mixed waste per year. The nature of the materials produced and handled at DOE facilities often results in the generation of waste with both radioactive and hazardous chemical properties. The "mixed waste" is regulated under both the Atomic Energy Act (AEA) and RCRA. Until recently overlapping jurisdiction had complicated the process of bringing DOE facilities into compliance with hazardous waste regulations.

DOE's final rule providing that all radioactive waste which is hazardous under RCRA is subject to regulation under both RCRA and AEA will bring a large number of facilities under the RCRA regulations and present a major challenge to DOE. Management practices which were in the past acceptable for radioactive waste are often not acceptable for hazardous waste. For example, the cribs at the Hanford, Washington facility were constructed to attenuate radioactive waste, but the chemical components of the waste which cannot be attenuated through the crib process may compound future cleanup costs through continued use.

In addition, the radioactive contaminated wastes often found at DOE facilities require specialized handling and cleanup technologies because of the increased dangers posed by direct contact with the wastes. In general, waste management problems at other Federal facilities more often can be handled through conventional technology application.

From Senator Johnston

Question 3: Are there other actions besides what DOE is already doing, that you would recommend to hasten DOE's progress in addressing environmental issues and bringing its facilities into compliance with current standards?

Answer: While DOE has made considerable progress in addressing environmental problems at its facilities, the Department has much to do to bring its facilities into compliance with federal hazardous waste management requirements. DOE must install groundwater systems and undertake closure actions and/or cleanups at hundreds of sites, and implement corrective actions to achieve full compliance with RCRA requirements.

EPA has encouraged DOE to develop a facility compliance accomplishment plan, similar to EPA's Superfund accomplishment plan, which would outline DOE's priorities for developing Federal Facility Compliance Agreements and Interagency Agreements, and address compliance and corrective action issues. This process would allow both DOE and EPA to focus initial attention on the major facilities that may pose the most immediate environmental concern. The plan would give DOE a tool with which it can plan its resource needs and assure adequate funding to attain compliance with waste management standards. EPA has offered to cooperate with DOE in developing such a plan. (See answer to Question 14.)

From Senator Johnston

Question 4: Are the environmental problems at DOE facilities solely due to past practices and problems, or is there evidence of ongoing problems at facilities?

Answer: At present, there are many DOE facilities which are not in compliance with RCRA requirements governing ongoing waste management operations. DOE is moving forward to correct RCRA violations through Federal Facility Compliance Agreements which address existing compliance issues. Corrective action for releases from a facility will be handled under RCRA Corrective Action Orders issued by EPA. Also, where EPA inspections have disclosed violations of RCRA groundwater monitoring provisions or closure/post-closure requirements, DOE is taking steps to return to compliance voluntarily or under an order or consent agreement.

From Senator Johnston

Question 5: Can you estimate the cost of cleanup and remedial actions required at DOE's facilities?

Answer: EPA does not have an estimate of DOE facility cleanup and remedial action costs. We have encouraged DOE, and other Federal agencies, to develop a facility compliance accomplishment plan with which DOE can establish corrective and remedial action priorities and plan its resource needs. Estimating cleanup costs at DOE facilities is much more complex than estimating costs for cleanup at private facilities. DOE facilities often encompass large areas which include multiple sites within a facility. For example, there are 1400 solid waste management units at the Hanford, Washington facility alone. We anticipate enormous resource needs to address the problems and encourage DOE to work with Congress to determine ways to meet those needs.

Many DOE facilities are large operations covering hundreds of acres. Several thousand solid waste management units (SWMUs) have been identified at these facilities that will require some kind of corrective action. In most cases, however, the extent of the problem has not been determined.

From Senator Ford

Question 1: Please explain what aspects of RCRA and CERCLA apply to Federal facilities.

Answer: By the express statutory language of §6001 of RCRA, Federal agencies are subject to the hazardous waste management provisions and objectives of RCRA. All active Federal treatment, storage and disposal facilities handling hazardous waste must have RCRA permits and must address releases of hazardous waste to the environment.

Federal agencies are also subject to the procedural and substantive provisions of SARA. The specific requirements for Federal agencies are found in §120 of SARA, which sets forth a process to ensure that Federal agencies assess and cleanup their hazardous waste sites within specified time frames, under EPA's oversight.

Question 2: Are Federal facilities subject to Administrative Orders issued under RCRA and CERCLA? Which Orders: (Please explain.)

Answer: The Departments of Justice and Energy and EPA are now in agreement that administrative orders can be issued to Federal agencies under RCRA §3008(h) and §3013 and under CERCLA §106. EPA intends to use these authorities to ensure Federal facility compliance.

Question 3: What kind of enforcement authority does EPA have available for DOE facilities? How will EPA use this enforcement authority at DOE facilities?

Answer: There are three important actions which EPA can take as a result of DOJ's recent testimony regarding EPA's enforcement authority. These relate to compliance issues under 3008(a) of RCRA and corrective actions under 3008(h) of RCRA. Following are EPA's interpretations of these items and a description of the process by which they will be applied to federal agencies and government owned contractor operated facilities (GOCOs).

1. Federal Facility Compliance Agreement

DOJ stated that EPA cannot issue 3008(a) compliance orders to other Federal facilities. Therefore, in the case where a Federal facility is not in compliance with RCRA, a Federal Facility Compliance Agreement (FFCA) will be negotiated. The FFCAs will contain enforceability clauses which will allow states or other citizens to enforce the agreements in the event of non-compliance. They would do so using the citizen suit provision contained in RCRA section 7002, which allows citizens to bring civil actions against any person (including the United States Government) alleged to be in violation of any requirement of RCRA. DOJ believes that the term "requirement" in RCRA section 7002 includes regulatory requirements and other items that are mandated by these requirements (e.g., schedules of compliance, various plans, recordkeeping, and reporting). DOJ believes that the requirements imposed by the final negotiated document are therefore enforceable.

Note that this discussion generally applies to violations of regulatory requirements; it does not extend to corrective action needs, which will be handled using EPA's order authority, as discussed below.

2. Corrective Action Orders (3008(h)) at Federal Facilities

With regard to corrective action and the issuance of Administrative orders under §3008 (h) of RCRA, DOJ has taken the view that all corrective actions are integral to the permitting process. Since §6001 of RCRA makes specific reference to permits, DOJ has concluded that administrative orders under §3008(h) can be issued to Federal facilities (i.e., the waiver of sovereign immunity extends to permitting, including corrective action requirements). Whenever action is required to correct problems of past contamination at a facility, EPA will use its order authority to correct such violations. Based on this DOJ determination, order authority under §3008(h) will be exercised whenever possible and appropriate.

In some cases there will be both corrective action and compliance issues at Federal facilities. In such cases EPA will negotiate a "Consent Order and Compliance Agreement" at the Federal facility. Both provisions could be enforced under §7002 by states or citizens.

3. Issuance of Orders to a Government Owned Contractor Operated Facility (GOCO)

DOJ has determined that EPA has the authority to take enforcement actions against the non-Federal operator of a facility to the same extent as against private parties. This authority is not limited to RCRA compliance issues under 3008(a). It includes corrective action authority under 3008(h) and response authority under CERCLA §106.

Enforcement actions using §3008(a) and 3008(h) of RCRA against GOCOs may be used at facilities where the contractor operates and conducts and does the majority of the waste management work. This is typically the case at DOE facilities.

The DOJ has also indicated that EPA has authority to issue section 106 administrative orders to Federal agencies. If EPA has difficulty negotiating an agreement under section 120 for CERCLA response actions at a Federal facility, an available enforcement option is a CERCLA Section 106 administrative order.

Question 4: What is EPA's position concerning corrective action under RCRA §3004 (u) at Federal facilities?

Answer: Section 3004(u) of RCRA requires corrective action of releases of hazardous waste and constituents from both active and inactive solid waste management units at facilities that have or are seeking a permit. All Federal treatment, storage and disposal (TSD) facilities must address any releases to the environment.

Question 5: Is the hazardous waste component of radioactive mixed waste subject to regulation as a hazardous waste under RCRA? For HLW and TRU also?

Answer: The hazardous component of mixed waste is subject to RCRA regulation independent of the nature of the radioactive constituent of the waste. That is, high-level, transuranic, and low-level radioactive materials are subject to regulation as mixed wastes if the waste exhibits characteristics of a hazardous waste or contains a listed waste.

Question 6: Is legislation needed to compel compliance at DOE facilities for mixed waste?

Answer: Historically, compliance at DOE facilities has not occurred in as timely a fashion as we might have found desirable. However, at this time, DOE appears to have put a new emphasis on environmental remediation and compliance at all of its facilities. Most recently, EPA entered into a Consent Order and Compliance Agreement with Idaho National Engineering Laboratories to effect compliance at this facility which will be used as a model for future settlements at other facilities. It is important to note, however, that environmental remediation can be quite costly, and funding must be made available. Nevertheless, based on this and other recent experiences, it does not appear that legislative intervention is necessary to ensure compliance.

Question 7: How will EPA compel compliance at Hanford and Savannah River Plant?

Answer: Negotiations are underway for fully enforceable agreements at Hanford and Savannah River Plant. Currently the State of South Carolina has the lead on enforcement activities at the Savannah River Plant. The State has already entered into four agreements under RCRA with DOE. A fifth order has been drafted to address Part B deficiencies and a sixth order will be drafted to address all outstanding violations. The agreements are fully enforceable by the State of South Carolina and citizens through the citizen suit provision of RCRA.

EPA, the State of Washington, and DOE are entering into negotiations for an enforceable agreement at the Hanford facility that will encompass cleanup requirements under both RCRA and CERCLA. The agreement will either take the form of a corrective action order under §3008(h) of RCRA or an Interagency Agreement under §120 of SARA. The agreement will be enforceable through the §310 citizen suit provision of SARA. The agreement will also be enforceable through the citizen suit provision of §7002 of RCRA. An enforceability clause, such as the one found in the corrective action order at Idaho National Engineering Lab, will lay out the citizens right to enforce under §310 of SARA or §7002 of RCRA.

Question 8: How is the public assured that hazardous Federal facility sites are targeted for cleanup?

Answer: Potentially hazardous Federal facility sites are identified to EPA through several reporting mechanisms including RCRA Section 3010 notifications, RCRA Section 3005 permitting applications, the RCRA Section 3016 biennial inventory of hazardous waste activities, and the CERCLA Section 103 release notifications. All Federal facilities that report to EPA under these provisions are included in the Federal Agency Hazardous Waste Compliance Docket, as mandated in CERCLA Section 120. The docket will be a publicly available repository of the information submitted to EPA by Federal agencies and will include notice of all subsequent actions taken regarding the facility under CERCLA and RCRA.

Section 120 contains schedules for assessing the hazard associated with each facility listed on the docket, and for evaluating such facilities for inclusion on the NPL if appropriate. Specific deadlines are also mandated for necessary investigations and remedial actions at Federal facility NPL sites. The public can monitor the cleanup progress at each facility by referring to the docket repositories and their associated community relations program.

The A-106 process is also a means of assuring that Federal facilities are targeted for cleanup. The process, outlined in OMB Circular No. A-106 of December 31, 1984, involves EPA as an advisor to Federal agencies and OMB on required funding levels for environmental projects, including identification, assessment and cleanup of hazardous waste sites. Project proposals are submitted to EPA for review and recommendations for reprogramming or redistributing resources. The process is one means by which EPA, Congress and the public can oversee environmental cleanups.

EPA and DOD are also initiating work on improving the process for involving states and communities in the setting of annual priorities for cleanup at Federal facilities. The process under discussion would result in an annual Federal facility accomplishments plan identifying the priorities for cleanup action nationwide, allowing EPA, the states, and Federal agencies to target their resources to the "worst sites first."

Question 9: When does the Agency plan to list and prioritize Federal facility sites?

Answer: In July 1987, EPA added 32 Federal facility sites to the NPL, the first Federal facilities to be included on the list. Sixteen Federal facilities remain in proposed status pending resolution of technical or policy issues or to complete review of comments. Additional Federal facilities will be included in the October 1987 proposal as well as a separate proposal in early 1988 specifically for Federal facilities.

Question 10: What other Federal agencies are faced with environmental problems such as those at DOE? Are DOE's problems worse in comparison? If so, why?

Answer: DOE's problems to a large extent are the result of past management practices for mixed waste. DOE practices for mixed waste have probably resulted in releases of wastes to the environment to a greater extent than other federal agencies. This situation may be attributed to a large extent to DOE's mission, namely, weapons production for national defense. In the last few years, DOE has begun to explore ways of accomplishing its mission in an environmentally sound manner. DOE has increased emphasis on environmental programs over the past several years, and environmental auditing programs have been established in efforts to develop a more consistent and accurate assessment of environmental conditions at their facilities. Efforts are now underway to do business in a more environmentally sound manner.

DOD, however, has a very large program, the Defense Environmental Restoration Program, which is dealing with more sites than DOE. It is specifically recognized by statute (SARA) and is funded by a separate annual appropriation. Many sites parallel the complexities of the DOE facilities, although they do not necessarily involve the same types of contamination. (See answer to Question 14.)

Question 11: Based on your current knowledge of the environmental problems at DOE facilities, how much money do you estimate it will take to resolve these problems?

Answer: Many DOE facilities are large operations covering hundreds of acres. Several thousand solid waste management units (SWMUs) have been identified at these facilities that will require some kind of corrective action. In most cases, however, the extent of the problem has not been determined.

Question 12: DOE recently signed a Consent Order and Compliance Agreement with EPA for RCRA activities associated with the Idaho National Engineering Laboratory. How did this Agreement come about? How will it be enforced? Will this Agreement serve as a role model for future agreements at other DOE labs? Are any such agreements in progress now? Where? Are there similar agreements being reached in the area of Superfund (CERCLA) requirements, or is this accomplished via a different process?

Answer: DOE and EPA began negotiations regarding the Idaho compliance and corrective actions problems over one year ago. Negotiations were pending over questions surrounding EPA's RCRA authority at Federal facilities. At a Congressional hearing that was held on April 27, 1987, the Department of Justice testified that EPA could issue corrective action orders under 3008(h) of RCRA to Federal facilities. Based on this decision, EPA formalized the agreement with DOE at INEL by entering into a corrective action order under 3008(h) with the facility. Conditions of the agreement are fully enforceable through the citizen suit provision of §7002 of RCRA.

DOE and EPA plan to use many of the provisions contained in the INEL corrective action order as model provisions for future agreements at other DOE labs.

Currently, negotiations are proceeding with DOE at the Lawrence Livermore National Lab in Lawrence, California for an interagency agreement under Section 120 of SARA. DOE, EPA and the State of Washington have also opened discussions on an agreement for cleanup of hazardous waste/substances at the Hanford facility. The type of agreement that will be developed for the Hanford facility has not been finalized.

Question 14: DOD has already done a lot with respect to hazardous waste cleanup. Are you following their work? How do they fund this work? Is their funding/accounting system a good example for DOE to use?

Answer: Yes, we are following DOD's work with respect to hazardous waste cleanup. We continue to be involved in reviewing DOD's preliminary assessments and evaluating facilities for inclusion on the NPL. We review their work for consistency with CERCLA and NCP. For facilities on the NPL, we are working with DOD to enter into Interagency Agreements to ensure EPA oversight of DOD's remedial investigation/feasibility study and implementation of the selected remedy.

DOD funds this work through the Defense Environmental Restoration Account (DERA). Congress appropriates funds to DERA and the Office of the Secretary of Defense is responsible for allocating funds to the Services — Army, Navy, Air Force, and the Defense Logistics Agency. There is DERA management guidance for use by each service's DERA managers. DERA has three priority sub-elements: Installation Restoration, Building Demolition and Debris Removal, and Other Hazardous Waste Operations. Each subelement has priority categories.

A key component in DOE's compliance strategy should be the use of a dedicated fund which would give environmental compliance and remedial action efforts a tool, separate from the Department's operating budget, with which it can set priorities and manage environmental problems. A dedicated fund approach to providing resources for environmental projects would allow the Department to plan for long term as well as short term projects, and would give Congress and the public an opportunity to examine the Department's plans and priorities.

Question 13: Are there any requirements of RCRA and/or CERCLA that would be inappropriate for EPA to apply to other Federal agencies, due to competing or conflicting roles of the various Federal agencies?

Answer: It is clear that the requirements of CERCLA/SARA and RCRA are applicable to Federal facilities. By the express statutory language of RCRA Section 6001, Federal facilities are subject to the provisions of RCRA and its implementing requirements. And CERCLA/SARA §120(a) states that the statute and all related guidelines, rules, regulations, and criteria are applicable to Federal facilities. The statutes provide national security waivers to protect the national security interests in the event that compliance with RCRA or CERCLA at a particular time would jeopardize the national security. The waivers should be applied on a site-specific and instance-specific basis and are not intended to routinely exempt response actions at Federal facilities from the public health and environmental standards imposed under the statutes.

Queston 15: Has DOE significantly improved its performance in environmental areas since formation of the Office of Environment, Safety, and Health?

Answer: The Office of Environment, Safety and Health has significantly improved the way DOE is approaching environmental issues by giving those issues a clear focus and a point of advocacy and visibility within the Department. Of particular note has been the increased willingness and desire on the part of DOE to work with EPA to address problems at DOE facilities.

For example, a DOE memorandum dated March 6, 1987, encourages field offices, as a matter of policy, to be the initiator of discussions or actions regarding compliance matters with EPA and the states. Another example is the first Federal facility corrective action order under 3008(h) of RCRA which was signed by DOE and EPA July 10, 1987 for the Idaho National Engineering Lab (INEL) in Region X. The Consent Order and Compliance Agreement (CO/CA) sets up a fully enforceable plan for addressing corrective action and compliance problems at the site. Mary Walker, Assistant Secretary for Environment, Safety, and Health followed up this agreement with a memo stating that DOE would like to use the language in the INEL CO/CA regarding enforceability and dispute resolution as model provisions and that this would "...greatly facilitate and expedite negotiations..." DOE is making progress on environmental issues at their facilities, although there is still a considerable amount of work to be done.

POST-HEARING QUESTIONS

Louis Roddis

July 17, 1987

July 30, 1987.

P.O. Box 1513,
Charleston, S.C.,29402.

Comments on Senator Johnston's questions.

1. You were Chairman of the panel that reported to the Secretary of Energy on the implications of the Chernobyl accident on the operations of the N-Reactor at Hanford. You recommended that the reactor be shut down and stay shut down. DOE plans to restart the reactor.

Why do you believe DOE decided not to follow your advice?

Is it your understanding that DOE is making a good faith effort to implement the recommendations you made for the case that DOE determines continued operation is warranted?

Do you have access to information about what DOE is doing?

How has DOE reacted to you and your work since your shutdown recommendation?

1. a. They did. The question does not capture my advice which was in summary:

i. If a long term need exists for weapons material build a new reactor as was planned to do in 1982, but never executed.
ii. Unless the reactor is essential for weapons material production, shut it down permanently.
iii. If determined by competent authority that the production is needed for national security reasons, shut it down and make a number of changes. Even then it will not last long.

If I understand correctly what the Department of Energy is doing it reaffirmed the national security need, it has shut down the "N"reactor for changes, and it is planning on requesting funds for a replacement reactor in 1989.

1.b. I believe that the Department of Energy is making a good faith effort to make the changes necessary to continue the operation of the "N" reactor for several more years. Since I am not aware of the exact plans, and since they appear to be only spending some one-quarter of their own estimate of the cost of all the recommended changes, they are apparently not doing all the things that I, and others, recommended.

1.c. I have no current access to what the Department of Energy is doing in this area, beyond what is in the public record. It has been suggested that a briefing of our consultant's group might be appropriate after the National Academy of Sciences report is made available. I would be willing to participate in such a briefing if we were allowed to submit written public reports on our individual findings.

1.d. At the senior Departmental level I have been told that our panel efforts are appreciated, and have influenced the decision making process regarding the "N" reactor. I could not expect more.

2. . Did you receive full cooperation from DOE in the work of your panel?

Were ther reports that you might have found useful that DOE didn't provide? What about the recently decassified 1966 report by R.E. Trumble on a "credible accident" known as a "delayed injection accident"?

Could you tell us about this accident, the Trumble report and the consequences of this report for your work on the post-Chernobyl analysis?

2. We received full cooperation from the Department of Energy and it's contractors during the entire conduct of our panel. I reflected my appreciation of this in my report. Information was freely and fully provided if it was available. Several studies and experiments are apparently in progress to develop some information which did not exist.

2.a. As is reflected in my report I thought that a great deal more information needed to be developed, especially in the areas of possible multiple cascading tube failures, of hydrogen evolution and control, of fire control, of radioactive waste discharge, back-up power supply reliability, to mention a few.

2.b. The 1966 Trumble report really raises the question of release of radioactivity to the environment from the disposal crib, which is a subject I addressed in my report, so our not seeing the report didn't have any effect on my recommendations. I have no idea why the report was not at least mentioned to our group. However the corporate memory of any large organization is far from perfect over a 20 year period.

3. Please clarify the remark in your oral statement about the effect of federal budget processes. I take it you do not think that DOE has requested, and/or Congress has not granted, adequate funds to make safety improvements at the N-reactor.

Please explain what you think has happened.

3. My statement about the Federal budget process is simply that it makes no special allowance for funding projects that are safety related. It treats nuclear safety, worker safety, and environmental concerns right along with operating budgets and geographical distribution of funding, with no special consideration.

In the civilian nuclear safety field, including licensed reactors of such Federal agencies as TVA, the situation is quite different. The NRC requires certain things to be done for safety reasons, and the licensee either pays to have them done or it does not operate the plant. Years later the utility may or may not recover these costs in rates, set either by themselves as in TVA, or by regulatory overview as in most utilities.

This situation is not unique to the nuclear safety area. It is for this reason that many Federal agencies, by no means only the Department of Energy, have been in violation of environmental regulations also.

For the "N" reactor it has been recognized by professionals for many years that it was getting old and needed to be replaced. This subject was studied extensively in 1982, but no fund request was made by the administration, nor to the best of my knowledge was any consideration given to the public report of the "Glennan Panel" report by any Committee of Congress. This 1982 report recommended that a contained replacement for the "N" reactor be built as soon as possible.

To my mind this is a failure of the entire Federal budget process to address a long term problem of national security implication. I am not an expert in how this process can be improved, but as a citizen I am concerned that the process is not working.

4. You have views on the institutional arrangements at these facilities. How can a proper balance between safety and the need for production be established?

Do you think such a proper balance exists now?

Does DOE put "safety first", as DOE spokespersons claim?

4. As I said in my prepared oral statement I think that the Departmental Organization can be improved in two ways to achieve an appropriate balance between safety and production.

i. Establish the Assistant Secretary of Safety Health and Environment on a statutory level, with authority, staffing, and funding appropriate for the function so that some future Secretary cannot reduce the present scope of the office.

ii. Establish by law a credible outside overview body that is required to publically comment on nuclear safety matters of the Department of Energy.

4.a. While the situation is improved I believe that many billions of dollars will have to be spent before the weapons material production chain reactors meet nuclear safety standards approaching those this country requires for commercial power reactors. There are also some important non-nuclear environmental problems involved on some of the associated facilities, which will also require funding.

4.b. While I do not doubt the intentions of the Department of Energy to consider that they put safety first, until the funding problems are addressed properly they are not really doing so. Safety costs money.

5. You recommend that the Advisory Committee on Reactor Safeguards be used by DOE to oversee nuclear facilities. If the ACRS declines this role, what kind of credible permanent outside review mechanism should be established?

A policeman and investigator such as the Inspector General?

An independent advisory board within the Department?

The Nuclear Regulatory Commission?

Please discuss.

5. I recommended the Advisory Committee on Reactor Safety for two reasons.

i. It is in existence and staffed. It at one time had an overview jurisdiction over the now Department of Energy Facilities before the AEC was broken up. Mechanisms exist to permit funding to be transferred to the ACRS for extra costs associated with reviewing Department of Energy facilities.

ii. Using the same technical review body will tend to provide a more uniform technical review of similar problems.

5.a. I do not think that an Inspector General approach is fruitful. A continued technically oriented appraisal and overview is what is neeeded at this level.

5.b. An independent advisory board within the Department can work if:

i. it is composed of knowledgable outsiders, part time,
ii. if there is a requirement that their conclusions be made public, in a timely manner,
iii. and if it reports to the Secretary directly.

5.c. See answer to 6. below.

6. Why shouldn't DOE operations just be made subject to regulation by the Nuclear Regulatory Commission?

What are the differences in the regulatory authority that would be feasible for:

DOE's defense materials production facilities?

R&D facilities?

Naval reactors program?

Waste management?

Other DOE programs?

6. I believe that putting the Departmental of Energy reactors under the NRC for licensing is bad policy for three reasons:

i. The NRC regulation is already overly legal, and establishing the legal precedents for one Governmental agency to regulate another is still in the budding stages with EPA. How this is going to work in practice is far from clear.

ii. Since most of the older Department of Energy facilities are uncontained and of several unique designs, the NRC would have to develop a new set of required criteria, and that would require significant staffing and time.

iii. I do not see how a dispute between the national security needs of the Nation and a local hazard risk can be settled with such a regulatory framework.

6.a. Presumeably the Department large reactors would be included, which include the defense materials production facilities and the R& D facilities. There are also a number of smaller critical facilities and reactors which would probably be involved.

6.b. see answer to 6.a. above.

6.c. I do not believe that the naval reactors program is now covered by the Department of Energy ES&H program. I believe they do make use of the ACRS on occasion.

6. e. I believe some aspects of the waste management program are already under NRC jurisdiction, but this is a very complex area and I have not studied it recently to a degree that I can give a full response to this question.

6. f. I would hope that the weapons test program, including some test facilities of reactor-like nature, do not come under NRC jurisdiction.

Louis H. Roddis, Jr.,
Charleston, S.C.

July 30, 1987.

Responses by Gerald F. Tape to Questions

Hearing on DOE's Defense Production Facilities
July 17, 1987

From Senator Johnston

1. Are you still a consultant to DOE? Since completion of your independent review of the N-Reactor, have you had any involvement with the Department's safety enhancement program? Has the Department consulted you at all in the upgrade program?

--If not, is there any particular reason why not?

--Would it be appropriate to continue as a consultant to the Department during this period of upgrading the facility?

Response

At the time the independent consultants were appointed, DOE requested Los Alamos National Laboratory (LANL) to provide them with administrative and technical support. Thus, I became a LANL consultant for this work. My contract is current through FY 1987.

At my request, I met with DOE Defense Programs Materials Production staff prior to the July 17, 1987 hearing in order to obtain an overview of the N-Reactor Safety Enhancement Program and its current status. This was not an in-depth review. The Academy report is yet to be completed and submitted to DOE. ESH and DP will then have to carry out their reviews. I can visualize a request from the Secretary for the consultants to review the totality of the SEP accomplishments in light of the Academy and DOE reviews prior to the N-Reactor start-up. I would be willing to participate in such an activity. Obviously, advance preparation could save precious time as the anticipated start-up date is approached.

2. Have the recommendations you made in your report been carried out by the Department?

--What recommendations have not been carried out?

--What concerns do you have about any recommendations that have not been carried out or will not be carried out?

Response

The recommendations made in my report are in the process of being carried out. Most of them called for study and evaluation followed by a determination of what corrective action, if any, should be taken. As stated in my prepared testimony, my recommendations are being addressed and work is underway. I have not reviewed the results of completed analyses nor of actions taken to determine the adequacy of up-grades or fixes. In many instances, final evaluation must await equipment and systems tests.

My report did include several observations for the Secretary's consideration. Two of these are explicitly addressed in my prepared testimony and are amplified later in the responses to questions 5, 9 and 12.

3. Is it your impression that the National Academy of Sciences will come out with additional recommendations for safety improvements to the N-Reactor, beyond those suggested by the independent panel members?

Response

I have not had contact with the Academy study group and cannot predict the outcome of their deliberation. Any new recommendations will have to be evaluated as to their importance, e.g. absolutely necessary, desirable, nice-to-have, etc. Also, the impact on "true safety" versus public perception must be considered.

As an aside and personal observation, it is difficult for a group, such as the Academy group, having expended so much time and effort, not to have additional recommendations, especially where the issue of safety is involved.

The Academy was asked to specifically address hydrogen issues. All of us are waiting for their findings and recommendations on this topic.

4. What is your opinion of Mr. Roddis recommendation in his October 1986 report for an inert confinement system for hydrogen control at the N-Reactor?

--Do you feel that DOE's alternative plans for addressing the issue of hydrogen control are sufficient?

Response

My report recommendation with respect to hydrogen was as follows:

> "III A. Re-evaluate the generation and control of hydrogen under accident conditions. Investigate the methods of prevention of build-up of explosive mixtures and detonation, for example, controlled burning, recombiners, inerting."

I was not prepared to say that hydrogen is or is not a problem for the N-Reactor. There was, however, sufficient uncertainty, and serious re-evaluation was necessary. The methods of control would then depend upon the nature of the problems. In my opinion, it was more important to re-evaluate before making a major commitment to inerting.

I am generally aware of DOE's present plans, whether they are sufficient will have to await the Academy's recommendations.

5. Do you feel that the Department has an adequate infrastructure in place to implement all of the necessary safety improvements in an orderly fashion and on a timely basis?

Response

DOE has given the N-Reactor Safety Enhancement Program (SEP) priority. The long shut-down has provided time and allowed personnel to devote their efforts to SEP implementation. As stated in my testimony, building up the technical expertise on the "regulatory side" of DOE over the last two years has been done somewhat at the expense of the "operating side." In examining the whole of DOE's reactor safety responsibilities, I find that the operating side needs a stronger reactor safety focus and a streamlining of the decision making process. (See question 12 for further amplification.)

6. Does the Department have sufficient funding to implement all of the necessary improvements?

Response

Funding for unplanned needs is always a problem in the Federal Government. Given the detailed budget and appropriation controls inherent in the U.S. system, there is little flexibility for Departments to respond to "emergencies." In the case of the N-Reactor, by virtue of the long shut-down and reprogramming, FY 87 funding is apparently adequate. I do not know what the situation will be for FY 88 and FY 89. There can be surprises resulting from new recommendations and, since the SEP is basically a success oriented plan, delays can be costly.

7. Do you feel that the safety of operations of the N-Reactor, or other DOE facilities, have been compromised because of the conflicting goals of safety and national security?

Response

I am not aware that safety at the N-Reactor has been compromised by security considerations nor have I made specific inquiries to ascertain whether it has or not. I am aware that security has demanded greater controls over ingress and egress to sensitive areas and that they can interfere at times with safety considerations.

More generally, conflicts between security requirements and safety requirements do arise, and I am concerned that, when such conflicts do occur, there be a rapid resolution of the problem. They do not get resolved expeditiously at the field level; a Headquarters quick decision is needed.

8. Have DOE's facilities been pushed beyond their limits in the interest of national security?

Response

The answer is no; however, the age of DOE's defense materials production reactors is of concern, and greater surveillance and attention to maintenance is necessary.

I assume that "in the interest of national security" means meeting defense materials production goals. In other words, has there been pressure to meet such goals at the expense of maintenance and deferred safety up-grades. To some extent, the answer must be yes.

Delaying maintenance and putting off actions until a later date is a phenomenon that permeates our whole society. It's easier to convince public bodies to fund new projects than to properly maintain on-going activities. The deterioration of bridges resulting from neglect is a common example. Deferring maintenance is looked upon by many as a cost-saving device. Many of the actions now being taken at N-Reactor under the SEP could have been implemented in prior years by accepting another few weeks of down-time with its concomitant loss of product.

I do not consider that DOE's facilities have been "pushed beyond their limits." I do consider that prudent planning would have included greater attention to maintenance and safety enhancement.

9. How can we avoid these conflicting goals? How do you suggest that we address the problem of balancing cost and risk that you mention on page 4 of your testimony?

Response

We can't avoid these conflicting goals, but, hopefully, we can become more rational in achieving a balance. The American way of life is more focussed on near term issues and less concerned about the future until a crisis develops. Energy is a perfect example. Also, we become more dependent on large, complex, advanced technology systems; response times to crises become long. Examples: time required to bring a new production reactor on line; time to revive the manned space program.

It has long been understood that individuals will accept a higher level of risk when they personally make the decision and realize the benefits; riding in an automobile is a common example. Even though a societal risk may be low, the fact that the damage may fall involuntarily on certain individuals tends to make all individuals less willing to accept the societal risk. A recent example is the pertussis vaccine. Not to use it would result in a far larger number of children being damaged than is now the case with its mandatory use. The solution is for the government to compensate the victims. This calls for leadership on the part of public officials and education so that the public can understand the risks to the individual and the costs to society of various alternatives.

The issue of defense materials production is more complex. The benefits are all societal, that is, national security. For those who wish to eliminate nuclear weapons completely, the risk of a reactor accident is eliminated; but the risk of future abrogation of a treaty or covert nuclear weapons build-up by a potential enemy then must be considered. For those who want insurance against such a possibility, the existence of materials production capability is the answer. These are complex issues that require understanding by the public and by public officials. Both Executive and Congressional leadership are required. As other nations have experienced, confidence in the leadership is a necessary factor in achieving public acceptance.

10. You mention on page 2 of your testimony that you found too much complacency about operations at the N-Reactor.

--Do you feel that this complacency is likely to be evident at other DOE facilities?

--Do you feel that the lack of independent oversight of these operations and facilities -- that is, the lack of anyone looking over operators' shoulders -- contributes to this complacency?

Response

Complacency in the context of operations that have become routine needs to be understood. How does the security guard whose job is to protect against terrorist attack maintain his alertness when he knows that the probability of a real event taking place in his life time is trivial? How does the reactor operator maintain his attention where he is accustomed to going weeks and months between shut-downs with no significant deviations from the routine? There are innumerable jobs where routine operations are commonplace. Even the most advanced technological systems have so much built-in automation that there is little for the operator to do but to start the operation and stop it. It is a challenge to management to maintain the employee's attention and skills to be able to respond properly to the unexpected. The problem is that long periods of successful and safe operations create a feeling of "it can't happen here." Witness the U.S. space program.

Management has many tools at its disposal. Positive motivation is more desirable than having big brother always looking over one's shoulder.

11. What type of independent oversight or peer review do you feel would be most appropriate and most successful for improving the quality of operations at DOE facilities?

Response

DOE's objective should be to achieve public confidence in its operational and regulatory activities as related to nuclear safety. In general, the public has more confidence in reviews and assessments made by independent external groups than in those performed in-house. The Secretary's utilization of the six independent external reviewers and the commissioning of the Academy review is a major step in that direction. The question now is how to institutionalize such reviews.

I favor a plan that does not create a new independent agency of government, that emphasizes cooperative and technological rather that adversarial and legal approaches, that retains decision making in DOE and that provides full information to the Executive and to the Congress. An Advisory Committee for Nuclear Safety (ACNS) analogous to the NRC's ACRS would be a key element in that plan. It would report to the Secretary and its reports would be made public.

DOE's continuing needs for external advice for the reactor safety program are limited. The major problem today has to do with the continued operation of the present reactors. External review, at present, is being carried out by the Academy Committee. In the next 5 to 10 years there may be 1 or 2 new reactors (production and/or research) which will require the equivalent of a licensing review. ESH is being structured to serve functions equivalent to those served by the NRC staff for NRC. The ACNS for DOE should be comprised principally of technical experts. Its work load, for the foreseeable future, would consist of oversight for the DOE reactors continuing in operation, "pre-licensing" activities for one or two reactors, and examination of specific nuclear safety issues that from time-to-time may arise.

12. You mention on page 4 of your testimony the problem of multi-layered and complex lines of authority and responsibility within the Department.

--Do you have suggestions for solutions to this problem?

Response

I will address this problem here only on the subject of nuclear reactor safety.

Issues of safety require rapid resolution and decision. An order to shut down should not be taken lightly nor made without full consideration of the consequences. As a practical matter, critical safety situations requiring immediate shut-down are more likely to be recognized by the contractor and action taken without DOE review. I am concerned that there is no single focus for reactor safety on the DOE operations side other than the Under Secretary. Each of three Program Offices has responsibility for those reactors under its jurisdiction. Also, five different Field Office Managers are in the chain. What expertise is available on the operations side is distributed widely.

I would suggest a small reactor safety group in Headquarters, expandable by addition of in-house and external experts as specific issues arise. This group would serve all three Program Assistant Secretaries as issues arise and would be administratively housed in the most technically knowledgeable Division, e.g. Nuclear Energy. The head of the group would have direct access to the Under Secretary. Field Managers would be responsible for maintaining relationships with the operating contractors, for keeping Headquarters informed and for participating in the decision process, but not for formulating personal official recommendations for Headquarters action.

For issues not involving shut-down but requiring resolution on actions to be taken, the chief of the Headquarters operations group, a Program Office representative, the Field Manager and the contractor's representative would serve as the project group to formulate recommendations and an action plan. ESH review and ACNS review as appropriate would be required before major actions would be ordered by the Under-Secretary.

Two objectives could be served by the above:

- Strengthen Headquarters operational safety role, and
- Shorten the decision process by eliminating a requirement for recommendations by the Field manager, but insure his participation in the decision making.

13. Why shouldn't DOE operations just be made subject to regulation by the Nuclear Regulatory Commission?
-- What are the differences in the regulatory authority that would be feasible for:

DOE's defense materials production facilities?
R&D facilities?
Naval reactors program?
Waste management?
Other DOE programs?

Response

In principle, DOE reactor operations could be regulated by the NRC. In practice it would be a mistake. My negative response is based on my view that NRC's process and actions are dominated by a legalistic approach with little concern for solving potential safety problems expeditiously. I firmly believe that enhanced safety results from a cooperative approach between operators and regulators in seeking solutions rather than approaches that are more adversarial and legalistic. A cooperative approach is more achievable within a technology oriented agency than between agencies where one is more technological and the other more legalistic in their approaches.

DOE's broad safety goals should be independent of the purpose of the reactor, i.e. production, propulsion, or research and development. Differences among reactor designs and operations will dictate different specific safety measures. Product needs will also influence the degreer of risk that could be taken. DOE's present problem is not one of being unable to build new facilities to NRC standards, but one ofoperating the present reactors at risk levels acceptable to the public. Such risks differ for the various applications and must be judged as to acceptability on a case-by-case basis.

I am not able to comment on the Naval Reactors, waste management or other DOE programs.

Natural Resources
Defense Council

1350 New York Ave., N.W.
Washington, DC 20005
202 783-7800

August 6, 1987

The Honorable Wendell H. Ford
Chairman, Subcommittee on Energy
  Research & Development
Senate Committee on Energy &
  Natural Resources
Washington, D.C. 20510-6150

Dear Senator Ford:

Please find below answers to the four questions you posed in your letter of July 27, 1987 regarding NRDC's testimony before the Senate Committee on Energy and Natural Resources concerning health and safety problems at DOE's nuclear weapons facilities.

1. What are the reasons that DOE has given you for why they do not feel it is necessary to conduct a full scale environmental impact statement prior to restart of the N-Reactor?

DOE has never provided NRDC with an explicit, written rationale for its decision not to prepare a full environmental impact statement (EIS), i.e. one which addresses the issue of whether the N-Reactor should be restarted and alternatives thereto. DOE was supposed to have provided such an explanation to the President's Council on Environmental Quality (CEQ) several months ago but CEQ has yet to receive this document.

In informal conversations, DOE representatives have argued that the reactor is not "shut-down" and therefore there is no decision to make regarding restart or alternatives which could be the subject of an EIS. Rather they contend that the N-Reactor is a "non-operating operational reactor" in "stand-down condition" for an "extended maintenance outage" (DOE's own words). We believe, however, that DOE is playing word games.

The case law is clear that a full EIS is required where a reactor, which has never been the subject of an EIS, is: (1) taken out of operation for almost one year; (2) plagued by serious safety problems identified by the

100% Recycled Paper

New York Office:
122 East 42nd Street
New York, New York 10168
212 949-0049

Western Office:
25 Kearny Street
San Francisco, CA 94108
415 421-6561

New England Office:
850 Boston Post Road
Sudbury, MA 01776
617 443-6300

Toxic Substances
Information Line:
USA: 1-800 648-NRDC
NYS: 212 687-6862

DOE's own consultants, two of whom have called for permanent shutdown of the facility; (3) the subject of up to $200 million worth of modifications; and (4) recently found to be in violation of federal and state environmental standards.

2. You state on page 6 of your statement that the Roddis panel review made it clear that the N-Reactor did not meet NRC safety standards.

   -- Should the reactor be required to meet current NRC standards, even though the facility was built and operated years prior to development of many of these standards?

All NRC-licensed reactors, including those dating from the 1960's, meet the reactor design and siting requirements of 10 C.F.R. 100, which predate even the N-Reactor. Even after renovation, the N-Reactor will not be capable of meeting the standards of 10 CFR 100 due to inadequacies in its containment design. This fact alone makes it unnecessary to reach the question of whether the reactor should have to meet other NRC standards applicable to new licensed reactors. Given that N-Reactor cannot fully meet requirements which apply even to vintage 1960's licensed reactors, and that there are no overriding national security reasons for operating the reactor over its remaining few years of useful life, the facility should remain shut down.

3. You state on page 7 of your testimony that installation of a containment system at the N-Reactor would cost only 10 to 20% of the cost of a new production reactor.

   -- Are you suggesting that we should install a containment at the N-Reactor instead of building a new production reactor, in addition to, or what?

The only way to bring the N-Reactor up to commercial safety standards, new or old, is to incorporate a containment structure that meets 10 C.F.R. 100. However, in view of the other safety problems with the reactor, and its limited remaining useful life, we do not advocate installation of a containment structure. We do believe, however, that addition of a containment structure is an alternative to the planned restart which should be considered in a full EIS.

4. Your testimony endorses NRC regulation of any new DOE facilities and suggests that any existing facilities also be held to commercial standards. But NRC has indicated its reluctance to license facilities that are already built and in operation.

    -- How do you propose that we deal with this?

We believe any new DOE production reactor, enrichment plant, or processing facility should be licensed and overseen by the NRC. NRC's reluctance to license existing facilities probably reflects the fact that several of these plants cannot meet NRC licensing standards. NRC has demonstrated a reluctance to deny any commercial reactor a license and undoubtedly does not look forward to confronting DOE with this prospect. However, the alternatives of permitting DOE to continue to operate its facilities in an unregulated manner or trying to duplicate NRC in a new agency are far worse. Consequently, we believe NRC should be given regulatory authority over existing facilities and where the Commission determines, in a licensing hearing or a more abbreviated process, that a plant cannot meet commercial safety standards, its operations should be phased out over a reasonable period of time.

Sincerely,

Dan W. Reicher

Dan W. Reicher

APPENDIX II

Additional Material Submitted for the Record

NATIONAL RESEARCH COUNCIL
2101 Constitution Avenue Washington, D C 20418

COMMISSION ON PHYSICAL SCIENCES,
MATHEMATICS, AND RESOURCES

COMMISSION ON ENGINEERING AND
TECHNICAL SYSTEMS

COMMITTEE TO ASSESS SAFETY AND
TECHNICAL ISSUES AT DOE REACTORS

August 26, 1987

Secretary John S. Herrington
Department of Energy
Washington, D.C. 20585

Dear Secretary Herrington:

On May 22, 1987, Dr. James F. Decker, the Acting Director of the Office of Energy Research, asked the Committee to Assess Safety and Technical Issues at DOE Reactors to review the technical adequacy of the Department's proposed approach to hydrogen mitigation at the N Reactor. I am writing on behalf of the Committee to respond to this request. The Committee will shortly submit another report that will discuss a range of other issues associated with the Department's production reactors.

The scope of the Committee's review of the proposed approach to hydrogen mitigation has been limited. As requested by the Department, we have focused on the overall advantages and disadvantages of the proposed approach. We have not performed a detailed design review. We have not reviewed operating procedures or training requirements, which are critical to the successful implementation of the approach. Moreover, we necessarily have relied on the accuracy of the detailed calculations in the materials that were submitted to us for review. Finally, our review has not addressed some of the more general assertions included in the contractor's documents. A list of the materials provided to the committee is appended.

In Part I of this letter we focus on the nature of the problem, the Department's proposed approach, and our principal conclusions. In Part II, we turn to a detailed discussion of specific issues. Both parts of the letter presuppose a basic familiarity with the relevant characteristics of N Reactor. These are described more fully in the materials provided to us for review.

I.

The protection of the public in the event of a severe accident at the N Reactor depends on maintaining the integrity of the reactor's confinement system -- the safety system that is designed to attenuate the release of fission products in the event of an accident. Because the confinement has not been designed for -- and is unlikely to be able to withstand -- hydrogen burns of any significant size, it is important that combustible concentrations of hydrogen be prevented within the confinement, except in very

The National Research Council is the principal operating agency of the National Academy of Sciences and the National Academy of Engineering to serve government and other organizations localized areas near the hydrogen source. In order to evaluate this issue, the contractor for the facility has conducted a series of analyses in which certain defined releases of hydrogen were assumed to occur in a number of locations within the confinement. The results of these analyses indicated to the contractor that, for the assumed rate and quantity of hydrogen released, there are only two locations in the confinement where combustible limits could be achieved -- the pipe-barrier space and the pressurizer-penthouse area. In other areas of the building, the contractor predicted that mixing would be sufficient to prevent a flammable concentration from being reached. The contractor further concluded that even if a burn were initiated in the pipe-barrier space, the increase in pressure would be dissipated in the larger volume of the confinement building and the confinement function would not be defeated. In order to mitigate the potential problem in the penthouse and to provide additional protection from the release of hydrogen in a severe accident, the contractor has developed a concept for a hydrogen mitigation system.

The proposed concept is intended to satisfy four basic functional requirements:

- Provide adequate mixing between subcompartments of the building to assure that burnable concentrations of hydrogen do not accumulate.
- Monitor hydrogen concentrations at various locations within the building.
- Fill the confinement with inert gas after the initial release of steam to assure that burnable compositions are precluded in the long term.
- Provide an exhaust system to displace air to support the inerting function and to establish a lower pressure in the building than outside the building, thus preventing outleakage through the walls and bypass of the filter system.

The first function is to prevent burnable concentrations of hydrogen. The second function provides information to plant staff that could be useful for identifying and mitigating severe-accident situations. The latter two functional requirements could be just as important in that, if properly implemented, they could provide a margin of protection in the event that releases of hydrogen are greater than the assumed hydrogen source.

The contractor considered alternative approaches to hydrogen mitigation. Preinerting and distributed ignition systems, which are methods for hydrogen control used in commercial reactors, were found not to be appropriate for the N-Reactor confinement system. The initial venting of the building atmosphere that occurs in the proper operation of the confinement system would defeat any preinerting system, and the confinement might not be able to withstand pressure pulses that could occur with a distributed ignition system, particularly for accidents involving large releases of hydrogen. This latter conclusion is consistent with the observation of pressure rises of many pounds per square inch in tests of ignition systems performed by the Electric Power Research Institute in a large-scale facility at the Nevada Test Site. Within the bounds of reasonable cost, there is no apparent preferred alternative to the concept proposed by the contractor.

The Committee's overall assessment of the general approach to hydrogen mitigation is favorable. In indicating its agreement with the general approach to hydrogen mitigation at N Reactor, the committee is not rendering a judgment as to the adequacy of the proposed system. Any judgment as to the adequacy of the system must be guided by an assessment of the general approach, careful analyses of the system under various hypothetical accident scenarios, evaluation of a detailed design, and construction and operation in compliance with appropriate safety standards. Because the analysis is only at a preliminary stage, this letter addresses only the first of these necessary factors.

The basic strategy of forced mixing to remove the potential for hydrogen pockets, monitoring of hydrogen at key points within the confinement, and the activation of an inerting/exhaust function appears to us to be sound. Indeed, the approach may provide a margin to accommodate some uncertainty relating to the amount of hydrogen generated in an accident. However, as discussed further in this letter, there are aspects of the underlying analyses and certain potential limitations of the proposed system that deserve further careful evaluation.

The principal aspects of the approach that merit further study or improvement may be briefly summarized:

- The system design is premised on a specific accident scenario. In the Committee's view, the predicted performance of the mixing and inerting systems should be examined for a broader spectrum of accident scenarios and release rates for hydrogen. For example, the assumption of the continuing operability of the Graphite and Shield Cooling System (GSCS) in the event of an accident needs a thorough examination, particularly in terms of any possible degradation of the GSCS in an accident.

- In the course of examining a broader spectrum of accident scenarios and hydrogen release rates, the contractor should extend the mixing calculations to address localized mixing and combustion. In addition, the contractor should examine the geometric configurations near possible release points in order to assure that localized concentrations of hydrogen do not permit local detonations that could challenge the confinement or other safety systems.

- The capability of the filter system to withstand the loading of aerosols in an accident should be reviewed and, if necessary, the capability of the system should be upgraded.

- The survivability of vital sensors and mitigation equipment should be assessed. The equipment must be capable of operating in severe-accident environments characterized by wide variations in thermal-hydraulic, radioactive and inert aerosol loads, and high radiation fields.

- The operation of the system necessitates the discharge of noble gases to the environment in the event of an accident. Although the operation of the system would decrease the risk of failure of the confinement following an accident, its operation would result in potential increases in whole-body doses to persons outside the plant. Means should be investigated to assure satisfaction of the dose limits of 10 CFR Part 100 without relaxing the speed with which inerting takes place. Such an investigation should take into account recent research that shows that the actual quantity and chemical form of the fission products released in a severe accident would be quite different from the source terms commonly assumed in such analyses in the past.

The Committee recommends that these concerns be resolved before the implementation of the proposed approach. The detailed design should be subjected to an independent review before hardware installation. Careful review of other aspects of the system, including operating procedures and training, is also warranted. In addition, prior to installation, the contractor should assess the effect of the proposed system on plant risk to determine whether the system would in fact result in lower risk to the public.

II.

There are a number of aspects of the proposed approach that warrant specific comment.

The Design Basis For The System

The accident scenario used as the design basis for the hydrogen-mitigation system was justified through a preliminary probabilistic risk assessment conducted by Los Alamos National Laboratory. In this scenario, the emergency core cooling system is assumed to fail following a large pipe break accident. An effort was made to be conservative in analyzing this accident and thus to provide for uncertainties, which at the present state of the analysis are substantial. The principal conservatisms in the analysis are the assumption of an unlimited supply of steam for the metal-water reaction (the source of the hydrogen) and the doubling of the hydrogen release that is calculated.

In our view the accident scenario that provides the design basis for the mitigation concept is not unequivocally conservative. We thus recommend that further consideration be given to alternative accident scenarios. Two assumptions in the current analysis clearly warrant increased attention:

- The analysis assumes that the cooling system for the graphite moderator (the GSCS) would be fully operational following an accident. The assumed continued operation of the GSCS reduces the calculated rate of hydrogen generation. This assumption should be validated from either a probabilistic standpoint (i.e., low probability of GSCS failure) or a mechanistic analysis (i.e., that the hydrogen source resulting from failure or degradation of the GSCS can be accommodated by the mitigation system).

- The analysis assumes that only a small fraction of the surface area of the uranium fuel is available for oxidation after melting. This serves to limit the extent of the metal-water reaction and thus the amount of hydrogen that is evolved. This assumption could be a major source of non-conservatism in the present analysis. More model development and experimental validation are warranted. Similarly, further consideration should be given to the possibility of catalytic enhancement of the reaction of graphite and steam, to the potential for fracturing of the zirconium oxide layer that is formed on the fuel during the presumed accident, and to the potential underestimation of the kinetics of zircaloy oxidation.

Although the Committee has concerns that the design basis for the hydrogen mitigation approach may not be demonstrably conservative, we believe that the approach provides a margin which, if maintained in implementation, may accommodate higher hydrogen release rates.

Hydrogen Monitoring System

The monitoring of hydrogen concentration within subcompartments of the confinement building is important because it provides information on localized conditions that can guide decisions in an emergency. The hydrogen monitoring system that is currently being installed measures the concentrations of hydrogen and oxygen electrochemically in ten sampling locations in key regions of the confinement volume. The system will require at least 30 minutes to cycle through the ten sample points to sample the entire confinement atmosphere.

The detection of hydrogen should not govern the activation of the hydrogen-mitigation system; the completion of the inerting function requires a number of hours and if it were not started until after hydrogen production is observed, it might be activated too late for the system to be effective. Furthermore, the 30-minute cycling interval is definitely longer than desired even if the measurements are not the sole guide for the activation of the hydrogen-mitigation system. Given the importance of timely information on the status of the system in an emergency, the capability for more rapid measurement should be sought and achieved. In addition, it is important that a monitor be placed near the point of release of the vent lines that connect with the dump tank for the reactor's depressurization valves, since this is the most likely point of release of hydrogen from the primary system for certain kinds of accidents.

Hydrogen Mixing System

Studies by the contractor have indicated that hydrogen concentrations after an accident would be expected to exceed the combustible limit (4 percent) in the small pressurizer penthouse if there were no forced mixing. The focus of the design for the mixing system, therefore, is to prevent the buildup of hydrogen in the penthouse. Redundant mixing fans with a capacity of 25,000 to 40,000 cubic feet per minute would remove air from the front face of the reactor and discharge it to the penthouse. Return flow through cross vents would provide for mixing of the major confinement volumes.

If the assumed hydrogen source term and the mixing calculations are reasonably accurate, the proposed mixing capacity should be fully adequate to prevent burnable concentrations (other than very localized concentrations at the break location) within the confinement. However, it is unclear how much margin exists in other regions, such as the pipe gallery and steam generator cells, in the event that hydrogen production rates should exceed the postulated hydrogen release. Hence, the Committee recommends more thorough evaluation of alternative accident scenarios and the uncertainties associated with calculations for hydrogen pocketing and stratification.

The basis for the concept of the mixing system derives from analytical simulations of hydrogen mixing in the N-Reactor confinement which indicate to the contractor that, with the exception of the pipe-barrier space and penthouse areas, natural-convection currents would be sufficiently strong to yield an essentially uniform concentration of hydrogen throughout the confinement volume. Validation of these analytical tools and their applicability to the problem of hydrogen mitigation at N Reactor (particularly with regard to the different scales of hydrogen stratification that may occur in the confinement) remain to be demonstrated. It is well known that calculated results for mixing processes in large open compartments are influenced by the degree of nodalization for lumped-parameter models and are subject to numerical diffusion errors for finite-difference codes. The Committee also recommends that the geometric configurations near possible hydrogen release points from the reactor coolant system be reviewed to assure that concentrations of hydrogen do not permit local detonations that could threaten the confinement or other safety systems.

Inerting/Exhaust System

The proposed inerting system would consist of redundant trains of nitrogen, supplied from stored quantities of liquified nitrogen, at a rate of up to 20,000 cubic feet per minute. Activation would follow primary system depressurization and the associated steam venting from the confinement following an accident. In order to allow the inflow of nitrogen without overpressurization of the confinement, an equal flowrate of air must be exhausted. In the proposed system, which has a maximum capacity of 23,000 cubic feet per minute, a negative pressure differential is expected to be achieved (relative to the atmosphere) shortly following the initial venting of the confinement. This has the benefit of reducing the subsequent direct outleakage of radioactive material through the walls of the confinement. This type of outleakage is a major contributor to the calculated doses, particularly thyroid doses, that are estimated in the current N-Reactor safety analysis report.

The contractor's calculations at N Reactor indicate that at the maximum rate of nitrogen introduction, with accompanying displacement of air from the confinement, inerting could be complete (less than 5 percent concentration of oxygen) in about 3.5 hours. Some hydrogen would also be displaced from the confinement by the nitrogen, further delaying the time required to achieve burnable quantities.

The Committee has examined the inerting capability using a simple single-volume model and assuming instantaneous mixing. We applied the model to study a range of hydrogen release rates into the confinement. The calculation reveals that a margin is available to cope with larger releases of hydrogen than are generated in the design basis scenario. This margin, if it in fact were achieved in implementation of the approach, serves to alleviate somewhat the Committee's concern that the postulated accident that serves as the design basis is not unequivocally conservative.

In order to achieve the extra margin, however, the system must be well mixed and the exhaust and inerting rate must be high (20,000 cubic feet per minute). The contractor did not provide adequate information to enable us to assess whether the mixing condition would be achieved, particularly for the steam generator cells. And care must be taken in implementation of the system to assure that rapid inerting can be achieved without accompanying releases that might compromise public health.

The operation of the inerting/exhaust system following an accident would discharge noble gases to the environment more rapidly than would the existing design, resulting in potentially higher whole body doses to individuals outside the plant. There is a direct tradeoff between the benefit of preventing hydrogen explosions through inerting and the cost of increasing the doses from noble gases. The implementation of the approach must provide a rapid inerting capability and assure compliance with the dose limits of 10 CFR Part 100. In this connection, it is important to recognize that assuring compliance with 10 CFR Part 100 involves uncertainties associated with operation of the confinement system that were not analyzed in the material provided to the Committee (for example, the confinement vent valves, the spray system, the filters).

Implemention of the contractor's proposal will also require careful reevaluation of the filter system. Higher exhaust flow could increase the aerosol loading on the filters and, hence, increase the likelihood of filter failure. Moreover, the decreased residence time of aerosols within the confinement system after an accident would decrease the effectiveness of the confinement sprays in removing aerosols from the atmosphere and thereby increase further the threat to the filter system. The potential aerosol source term, the spray effectiveness in the removal of aerosols, and the failure criteria for overloading of the filters require careful examination by the contractor.

Other potential failure modes of the confinement system that stem from the activation of the hydrogen-mitigation system also warrant scrutiny. For example, the injection of cold nitrogen into the confinement in conjunction with operation of the fan exhaust system could reduce the pressure in the confinement, possibly challenging the structure. Careful examination of the interaction of the hydrogen-mitigation system with the confinement design and operation is necessary.

Finally, it should be recognized that, as with any inerting system, there is a possibility of accidental actuation. Careful controls must be employed to prevent inadvertent actuation of the system and to alert personnel located in the building in the event it occurs.

Design, Control System, Procedures, and Training

The hydrogen mitigation concept has not developed to the point at which the details of the design, the control system, the operating procedures, and the training programs can be assessed. It is clear, however, that successful implementation of the concept must rely on the careful development and implementation of these elements. Accordingly, we recommend a detailed independent review of each of these elements.

* * *

We hope that these comments are helpful. Please feel free to contact the Committee if we can provide any further assistance.

Sincerely,

Richard A. Meserve
Chairman

cc: Joseph F. Salgado
James F. Decker

Department of Energy
Washington, DC 20585

September 11, 1987

Dear Mr. Chairman:

The Inspector General of the Department of Energy (DOE) recently concluded an investigation which I had requested of the disclosure of information concerning the Emergency Core Cooling System (ECCS) capability of the reactors at our Savannah River Plant. I am forwarding a copy of the report of investigation, and my response to the Inspector General, for your information.

The investigation indicates that the contractor found a miscalculation of the capacity of the ECCS to respond to a worst case loss of coolant accident. The contractor, E.I. Dupont de Nemours & Company, delayed in reporting this matter to DOE while it examined the issue further. When the issue was brought to our attention, we immediately reduced power at the facility to assure safe operation. After consultation with the National Academy of Sciences concerning the sufficiency of the reduction, we further limited the plant's output.

As indicated in my report to the Inspector General, actions have been taken by the Savannah River Operations Office, and the Department's Office of Environment, Safety and Health, to avoid this situation in the future. The reactors continue to operate at a reduced level, within the capabilities of the ECCS to respond to an accident.

The Department remains committed to the safe operation of our nuclear complex. Our reaction to the circumstances at Savannah River confirms our responsiveness to outside examination as well as our ability to respond immediately to safety issues.

Please do not hesitate to contact me if you have any questions.

Yours truly,

Joseph F. Salgado
Under Secretary

Enclosures

Honorable J. Bennett Johnston
Chairman, Committee on Energy
and Natural Resources
United States Senate
Washington, D.C. 20510

Department of Energy
Washington, DC 20585

September 9, 1987

MEMORANDUM FOR: John C. Layton
Inspector General

SUBJECT: Response to Abstract Report of Investigation:
Disclosure of Information Savannah River Plant
I87SR010

This is in response to your request for comments concerning the above report.

The Manager of the Savannah River Operations Office, Mr. Robert L. Morgan, took prompt and appropriate action upon learning of the Emergency Core Cooling System (ECCS) issue. The operations office has since implemented several changes in program management and oversight functions to assure that the contractor is responsive to all the Department's orders and procedures, including the need for immediate and candid communication on matters related to safety. Among the actions taken or reinforced by Savannah River (SR) are:

- weekly meetings between the management, at both the middle and senior levels, of the contractor, E.I. Dupont de Nemours and Company, and SR;
- SR membership on Dupont committees, e.g. the ECCS Action Plan committee;
- attendance by SR at Dupont Reactor Safety Oversight meetings;
- a Laboratory Overview Council to improve communications between SR and the contractor-run laboratory;
- formal transmittal of Laboratory Reactor Research Reports to SR;
- participation in the review of Dupont's management controls through an outside consultant.

It is apparent from the nature of the contractor's contact with the Savannah River Operations Office that there was a lack of sensitivity to the significance we place on the communication of safety issues. As operating contractor, Dupont should have recognized that the ECCS issue, even in its preliminary stage of assessment, would be a matter of importance to DOE, and should have brought it to the attention of the Operations Manager. Based on the actions taken by the Savannah River Operations Office, noted above, this situation should not arise in the future.

The Office of Environment, Safety and Health has been tasked with strengthening notification procedures to assure that safety related information is brought to its attention immediately. In May, I approved a program to improve problem reporting, including:

- compiling a reference of DOE reporting requirements;
- providing guidance for site-specific reporting requirements;
- preparing site specific implementation plans;
- analyzing data for problem areas.

In addition, as a follow-up to these actions, I have issued a memorandum to the Operations Offices requiring that matters concerning public and facility safety, including any matter pertaining to the operation of our nuclear facilities, be reported directly to the Assistant Secretary for Environment, Safety and Health, at the time notice is given to the program office. This action will assure that issues bearing on public safety and facility integrity are given immediate attention by all responsible organizations.

In addition, the Department's Orders will be reviewed and additional actions will be developed as necessary to ensure that all elements of the Department and its operating contractors properly implement the Secretary's commitment to safety.

I believe these actions are responsive to the issues examined in your investigative report and will strengthen this Department's commitment to the safe operation of its facilities.

Joseph F. Salgado
Under Secretary

United States Government Department of Energy

memorandum

DATE: August 4, 1987

REPLY TO ATTN OF: IG-1

SUBJECT: Transmittal of Abstract Report of Investigation, Disclosure of Information, Savannah River Plant (SRP) (Case I87SR010)

TO: Under Secretary

Attached is an Office of Inspector General (OIG) Abstract Report of Investigation concerning disclosure of information regarding reactor emergency cooling by Savannah River personnel to a National Academy of Science (NAS)/National Academy of Engineering (NAE) Committee.

The investigation was predicated on issues referred by the Under Secretary on March 20, 1987, as well as an issue raised by The Washington Post and issues developed during the investigation. The issues and summary findings are as follows:

(1) Was the NAS/NAE Committee provided information they requested and that was available regarding SRP reactor cooling?

Investigation determined that information regarding the reactor emergency cooling system (ECS) issue and the related experiments that led to a reduction of SRP reactor operating power limits on November 25, 1986, was not provided to the NAS/NAE Committee during their October 1986 visit to SRP. The investigation did not develop evidence the information was deliberately withheld from the NAS/NAE Committee or the Committee was denied information they specifically requested.

[redacted] a NAS/NAE Committee member [redacted] SRP reactor emergency cooling, said [redacted] was convinced officials of E.I. du Pont de Nemours & Company (Dupont) made a conscious effort not to [redacted] of the ECS issue during [redacted] visit to SRP in October 1986. [redacted] obtained information regarding the ECS issue in a [redacted] visit to SRP.

[redacted] Dupont-SRP, said the experimental work on the ECS issue was very preliminary at the time of the NAS/NAE Committee's visit in October 1986. [redacted] said Dupont personnel were not ready to discuss it with the Committee since it had not been discussed with Dupont management or DOE Savannah River Operations Office (SR) officials. [redacted] said [redacted] a member of the NAS/NAE Committee, asked Dupont officials to respond to questions in terms of current reactor operations. [redacted] said Dupont personnel responded to Committee questions regarding the reactor ECS in terms of the ECS-related experiments conducted in 1979, which were documented and the basis for the current reactor power levels. When Committee members requested documents regarding the reactor ECS, they were not provided documents regarding the recent ECS-related experiments, since the experiments were not documented.

[redacted] said it was not inconceivable that during the October 1986 Committee visit to SRP [redacted] had asked Dupont personnel to base their responses on the existing basis for reactor operations. [redacted] felt it would have been natural for Dupont personnel to mention the reactor ECS issue. [redacted] said Committee members asked questions all around the ECS problem area, but did not ask the right questions.

It was further determined that briefings to Committee members during their October 1986 visit to SRP provided an opportunity for discussion of the ECS-related experiments. [redacted] Dupont-SRP, referred in general terms to the ECS-related experiments when [redacted] mentioned calculations had been made regarding the flow and power in the individual fuel assemblies to determine if they were cooled. [redacted] gave a detailed description of the design basis loss of coolant accident (LOCA) involving the reactor ECS, which was the basis for the ECS-related experiments. [redacted] was interrupted by questions from Committee members about ECS pumps and motors. Subsequent discussion of the ECS design basis LOCA was primarily hardware-oriented.

(2) When did DOE-SR officials learn that changes in reactor ECS limits would require a reduction in SRP reactor operating power levels?

Investigation determined the earliest DOE-SR officials knew for certain that changes in ECS limits would require a reduction in reactor power levels was November 25, 1986, the day the power was reduced.

It was determined that [redacted] DOE-SR, knew in July-August 1986 the ECS limits could be more restrictive than in the past and could impact SRP reactor power limits in the winter months. [redacted] was told by Dupont officials that a project for a fourth addition to the reactor ECS was needed to gain back reactor power if the experiments led to reduced operating power levels.

[redacted] said [redacted] office should have been aware of the ECS issue, but was not. There was no indication of a problem with the ECS limits in July-August 1986 when [redacted] learned Dupont was conducting ECS-related experiments. [redacted] next heard of the ECS issue on November 24, 1986, when Dupont officials told [redacted] a possible change in ECS limits may affect reactor power levels in cold weather.

It was further determined that DOE-SR safety officials knew Dupont's Savannah River Laboratory (SRL) was conducting ECS-related experiments. [redacted] Office of Health, Safety and Environment, DOE-SR, said the ECS issue "fell through the crack."

(3) When did DOE Headquarters officials learn of the November 25, 1986, reduction in SRP reactor power levels?

Investigation determined DOE Headquarters officials learned of the ECS issue and associated reactor power reduction on November 25, 1986, from Mr. Robert C. Morgan, Manager, DOE-SR, who notified Ms. Jo Ann S. Elferink, Executive Assistant to the Under Secretary, and Mr. John L. Meinhardt, Deputy Assistant Secretary for Nuclear Materials, Office of Defense Programs.

It was further determined that senior officials of the DOE Office of Environment, Safety and Health (ES&H), learned of the ECS issue and related reactor power reduction at a staff meeting on December 1, 1986.

(4) Was the ECS issue identified by the NAS/NAE Committee found by a DOE-ES&H Design Review Team during their review of SRP reactors in November 1986?

Investigation determined that the Design Review Team did not find the specific ECS issue identified by the NAS/NAE Committee.

(5) Although asked by members of the Senate Governmental Affairs Committee during [redacted] about the results of the NAS/NAE Committee review of SRP reactors, did [redacted] fail to disclose a March 9, 1987, warning by the NAS/NAE Committee that "the SRP reactors were operating beyond the capacity of their cooling systems, threatening a catastrophic core melt in the event of an accident"?

Investigation determined [redacted] did not disclose the March 9, 1987, NAS/NAE letter

It was determined that Committee members did not ask [redacted] about the results of the NAS/NAE review of the SRP reactors. The questions by Committee members concerned an NAS review of the Department's "N" reactor at Hanford, Washington.

It was further determined that the NAS/NAE Committee's March 9, 1987, letter to the DOE Secretary did not state "the SRP reactors were operating beyond the capacity of their cooling systems, threatening a catastrophic core melt in event of an accident."

This Abstract Report of Investigation is provided for your use in determining the appropriate administrative action warranted. It is the property of the Office of Inspector General and should be protected in accordance with provisions set forth in the Privacy Act, Title 5, U.S.C., Section 552a.

I would appreciate your office providing a written response within 30 days concerning any action taken or anticipated.

John C. Layton

John C. Layton
Inspector General

Attachment
As Stated

Abstract Report of Investigation

Disclosure of Information

Savannah River Plant

I87SR010

PREDICATION

On March 20, 1987, Mr. Joseph F. Salgado, Under Secretary, Department of Energy (DOE), requested the Office of Inspector General (OIG), DOE, determine if a National Academy of Science (NAS)/National Academy of Engineering (NAE) Committee that reviewed the safety of the nuclear production reactors at the Department's Savannah River Plant (SRP) was provided the information they requested and that was available regarding reactor emergency cooling. A March 23, 1987, article in The Washington Post stated

about the results of the NAS/NAE review of SRP reactors, but did not disclose a March 9, 1987, warning by the NAS/NAE Committee to the DOE Secretary that "the SRP reactors were operating beyond the capacity of their cooling systems, threatening a catastrophic core melt in event of an accident."

Based upon the referral, The Washington Post article, and subsequent interviews, the OIG focused on the following summary issues:

(1) Was the NAS/NAE Committee provided information they requested and that was available regarding SRP reactor cooling?

(2) When did DOE Savannah River Operations Office (SR) officials learn that changes in reactor emergency cooling system (ECS) limits would require a reduction in SRP reactor operating power levels?

(3) When did DOE Headquarters officials learn of the November 25, 1986, reduction in SRP reactor power levels?

(4) Was the ECS issue identified by the NAS/NAE Committee found by a DOE-ES&H Design Review Team during their review of SRP reactors in November 1986?

(5) Although asked by members of the [redacted] about the results of the NAS/NAE Committee review of SRP reactors, [redacted] fail to disclose a March 9, 1987, warning by the NAS/NAE Committee that "the SRP reactors were operating beyond the capacity of their cooling systems, threatening a catastrophic core melt in event of an accident"?

RESULTS OF INVESTIGATION

Issue 1: Was the NAS/NAE Committee provided information they requested and that was available regarding SRP reactor cooling?

Documentary evidence showed as early as 1982, personnel of the DOE-SR support contractor, E.I. du Pont de Nemours & Company (Dupont), expressed concerns with ECS-related experiments conducted by Dupont in 1979. These concerns were the basis for additional ECS-related experiments initiated by Dupont in 1985. On May 13, 1986, the DOE Secretary requested the NAS/NAE form a committee to assess the safety of the Department's nuclear reactors. On November 25, 1986, the operating power levels of the SRP production reactors were reduced by 20 percent based on experimental data and calculations that indicated reactor fuel assemblies might not be adequately cooled during a design basis loss of coolant accident (LOCA) involving the reactor ECS.

Documentary evidence showed the postulated worst case LOCA for the SRP reactor ECS was a double-ended pipe break in the process water line, which is assumed to include one of the three reactor ECS addition systems, and a failure in one of the two remaining reactor ECS addition systems, leaving one reactor ECS addition system to provide cooling water after reactor shutdown. Thermal-hydraulic limits, which include ECS limits, are the most important set of limits imposed for safe operation of the SRP reactors. ECS limits, if lower than other limits, can become the operating limit for reactor operations and are implemented by restricting reactor and fuel assembly operating power levels.

[redacted] said the Committee's initial visit to SRP during October 29-31, 1986, consisted of briefings, interviews with groups of DOE-SR and Dupont officials and a "closeout" with these officials. The closeout did not include a disclosure of the Committee's findings. During the October 1986 visit, there was no hint of uncertainties with safety margins associated with the reactor ECS or reactor power levels and Dupont personnel never spoke to the problem. There were two issues regarding SRP reactor operations that were subsequently identified by the NAS/NAE Committee. One issue involved flow instability that occurred within the initial two seconds after reactor shutdown; whether there was adequate flow to the individual annuli of the reactor fuel assembly channels and if the reactor ECS survived the phenomenon. The second issue was whether the reactor ECS provided adequate flow to the reactor core if it survived the initial two seconds after reactor shutdown. [redacted] was certain [redacted] questions during the October 1986 visit that should have elicited a response from Dupont personnel regarding the ECS problem. After their visit to SRP during February 5-6, 1987, [redacted] and [redacted] shared their concern that the ECS problem had not been adequately addressed with other NAS/NAE Committee members, several of whom visited SRP during February 25-26, 1987, to determine the basis for the concerns. The Committee members met with [redacted] Dupont Staff Engineers, and requested a written response to the Committee's concerns. After reviewing Dupont's written response, which did not put the issues to rest, the Committee advised the DOE Secretary of their concerns in a letter dated March 9, 1987.

[redacted] a member of the NAS/NAE Committee, said [redacted] area of interest was the reactor ECS and, regarding a LOCA, whether sufficient cooling was available or the reactor power levels too high. During the October 1986 visit to SRP, [redacted] met mostly with managers and not with the individuals doing the actual work. During discussions in February 1987 with [redacted] learned of the reactor ECS problems found [redacted] said the reactor ECS problem involved boiling in the reactor channels, the possibility of resultant "flooding" between two counter-current streams, and associated instabilities. From [redacted] discussions with [redacted] recognized a potential for "flooding" of the reactor ECS. During [redacted] October 1986 visit, [redacted] asked Dupont officials about boiling in the reactor channels and was told there was none. [redacted] said that would have been the time for Dupont officials to mention the reactor ECS issue, since it involved boiling so strong the reactor could not be cooled. When [redacted] told there was no boiling, it cut off any follow-on questions regarding flooding. [redacted] said Dupont officials should have brought the reactor ECS problem to the NAS/NAE Committee's attention in October 1986, since it was apparently a source of major controversy among Dupont personnel at the time. [redacted] was convinced

Dupont managers made a conscious effort not to tell [redacted] of the reactor ECS problem.

[redacted] a member of the NAS/NAE Committee, said that during meetings [redacted] attended with [redacted] on the last day of their October 1986 visit to SRP, Committee members asked very specific physics-related questions. Dupont personnel, who were mostly managers, provided very specific responses. Dupont personnel responded well to hardware/equipment oriented questions. Their responses to detailed physics questions were fragmented and the discussions did not flow logically because the managers did not know the answers and brought in knowledgeable people to respond. Committee members asked questions [redacted] would have elicited a response from Dupont personnel about the reactor ECS problem, but a response would have disrupted the flow of the discussions because it would have been from "left field." [redacted] Committee members asked questions all around the ECS problem area and it would have been natural for Dupont personnel to mention the reactor ECS problem. [redacted] said since Committee members did not ask the right question, Dupont personnel were consistent by only providing specific responses to specific questions. There was no indication during the October 1986 visit of the reactor ECS problem that subsequently led to a reduction in SRP reactor operating power levels. [redacted] did not feel Dupont personnel had lied by not telling the Committee members. During [redacted] January 22, 1987, Dupont personnel discussed the November 1986 power reduction and the reasons for it. Although Dupont personnel did not appear to hold anything back, [redacted] subsequently learned of the technical uncertainty and the long history of disagreement among Dupont personnel regarding the ECS issue, which had not been apparent in their responses. [redacted] said it was not inconceivable that during the October 1986 visit [redacted] asked Dupont personnel to restrict their responses to the existing basis for reactor operations. There were a lot of improvements underway and [redacted] did not want Dupont personnel to talk about all their improvements and not focus on current operations.

[redacted] a member of the NAS/NAE Committee, said although [redacted] SRP reactor confinement systems, [redacted] was asked [redacted] during the October 1986 visit to SRP to attend a meeting on hot water flow in hot channels. [redacted] asked questions like "Do you get boiling in the channel when the cooling system comes on?" After an initial response that there was no boiling, Dupont personnel responded that there was boiling in the end of the channel. [redacted] asked mostly physics-type questions and received responses [redacted] [redacted] was not aware if [redacted] asked catch-all type questions like "Are you aware of any problems or are there any concerns regarding the reactor ECS?" [redacted] was not as concerned [redacted] that Dupont personnel may have known of the reactor ECS problem and not told the Committee in October 1986. [redacted] did not recall any specific questions by Committee members during meetings [redacted] attended that would have elicited a response from Dupont personnel regarding the reactor ECS problem. During a subsequent visit to SRP, [redacted] obtained all the information about the reactor ECS problem [redacted]

[redacted] NAS/NAE Committee, said at no time in meetings [redacted] attended during the Committee's October 1986 visit to SRP were questions asked that would have elicited a response from DOE-SR or Dupont personnel regarding the reactor ECS problem. [redacted] did not regard the failure of Dupont personnel to provide information on the reactor ECS problem at that time as a misrepresentation on their part.

[redacted] Dupont Savannah River Laboratory (SRL), said experiments by Dupont-SRL in 1979, which examined blockage in individual fuel assembly channels and the relationship of reactor power versus cooling water flow, led to the conclusion that the SRP reactor ECS was adequate to meet the design basis LOCA scenario. The experiments were followed by several years of dialogue within Dupont, during which questions were raised on the validity of the experiments. Experiments initiated [redacted] in 1985 showed reactor ECS limits might be more restrictive than earlier experiments indicated. A Dupont peer review group reviewed [redacted] work during September-October 1986 to determine if there was a defensible basis for [redacted] preliminary conclusion that revised reactor ECS limits could impact SRP reactor power limits in the winter months, beginning December 1, 1986. The peer review group had difficulty reaching a consensus on the reactor ECS issue. During the same period, considerable management attention was directed to the pending visit of the NAS/NAE Committee in late October 1986. [redacted] said Dupont personnel could have discussed the reactor ECS issue with the NAS/NAE Committee during their October 1986 visit, but chose not to. It was not a significant issue and limited time was allotted for briefings. Dupont officials did not deliberately attempt to keep the reactor ECS issue from the Committee and a number of other experiments that Dupont personnel were working on were also not mentioned.

[redacted] Dupont-SRL, said the ECS limits had always been high and other limits were considered more critical since they were a more probable source of an accident from an operating standpoint. A management decision was made to review the 1979 ECS-related experiments and the reactor ECS issue as time permitted, which subsequently led to ECS-related experiments being initiated [redacted] around January 1985. [redacted] work was subjected to an informal peer review in September 1986. A formal peer review was begun in October 1986. About the end of October 1986 it appeared the results of [redacted] work would lead to a reduction in the reactor power limits in the winter months, but there was disagreement among Dupont personnel whether there actually was an ECS problem. Although there had been some awareness of the ECS issue, the consensus was the information regarding the impact of the ECS issue on reactor power levels started up the management chain coincidental with an October 31, 1986, memorandum [redacted] on the subject. [redacted] said Dupont viewed committees, such as the NAS/NAE Committee, as a "cross to bear", since meetings required time and effort by Dupont personnel and recommendations by such groups were not very helpful. Dupont's philosophy was to answer all questions at such meetings, but not to volunteer new information, which usually appeared in the committee's report before Dupont had a chance to finish their work. [redacted] said Dupont treated the NAS/NAE Committee like any other committee, which was probably a mistake.

[redacted] said [redacted] on June 6, 1986, that [redacted] was certain the ECS limits would restrict reactor power limits. Although it was not completed, several people began a review of [redacted] work during September 1986. Numerous people were questioning [redacted] work and the results and there were intense meetings. [redacted] felt [redacted] findings were being treated as an embarrassment. Various people were skeptical of [redacted] results and not pleased a mistake had been made in the 1979 experiments. [redacted] was not able to complete [redacted] work and finalize the ECS issue because [redacted] was tied up in meetings. Near the end of October 1986 [redacted] was told to avoid meetings and [redacted] best answers on the ECS issue by December 1, 1986.

[redacted] Dupont-SRP, said there was not time during briefings to the NAS/NAE Committee in October 1986 to provide much detail. A good portion of the briefing regarding the reactor ECS was spent on hardware, with not much in-depth analytical discussion. The experimental work on the ECS issue was very preliminary in October 1986 and Dupont personnel were not ready to discuss it with the Committee. At that time, it had not been discussed with Dupont management or DOE-SR. [redacted] told [redacted] other Dupont personnel that [redacted] wanted to address only current conditions and not future projects and innovations. When Committee members asked questions concerning the basis for certain calculations regarding the reactor ECS, the responses by Dupont personnel were based on the 1979 experiments. These were documented and had been used as a basis for the existing reactor power levels. When Committee members requested documents concerning the reactor ECS, the documentation provided by Dupont did not include [redacted] work, which was not documented. The discussions [redacted] did not flow logically because of the types of questions they asked and the lack of technical personnel available to answer them. [redacted] said a question was asked during the October 1986 visit regarding flow instability. [redacted] did not recall any questions about boiling during a design basis LOCA involving the reactor ECS.

[redacted] Dupont-SRP, said the subject of boiling in the reactor ECS was raised during informal sessions on the first day of the NAS/NAE Committee's visit in October 1986, but not in subsequent meetings [redacted] attended. During [redacted] briefing to Committee members regarding hardware aspects of the reactor, [redacted] a viewgraph showing a schematic of the reactor ECS plumbing and [redacted] a viewgraph titled "Emergency Core Cooling." The last bullet on the viewgraph was "Continuing Reanalysis and Improvement." [redacted] said the appropriate time to discuss ongoing work regarding the ECS issue was when [redacted] the viewgraph. [redacted] mentioned the Dupont-SRL work regarding the reactor ECS in general terms, but did not discuss the specifics. The ECS issue was not considered significant at the time and it was not clear where the work was leading.

Documentary evidence showed [redacted] mentioned [redacted] work to the NAS/NAE Committee, but in general terms. The verbatim transcript of [redacted] briefing to the Committee showed [redacted] was asked whether [redacted] planned to discuss the evaluation of pushing emergency coolant into the reactor and the possibility of a fuel assembly channel being hot and having steam locking. [redacted] said [redacted] had not planned to discuss the matter in detail. [redacted] said calculations had been made and a limit placed on the reactor based on that flow, distribution and power distribution for emergency cooling capability. Also, complex calculations had been made by Dupont regarding the flow and power in each of the 600 individual fuel assemblies to determine they are cooled. Subsequently, [redacted] said "... our problem is that we are not aware of the things we know that you don't know, and if you persist, the truth will come out." The transcript [redacted] provided a detailed description of the scenario for the worst case design basis LOCA involving the reactor ECS, which was the basis of [redacted] ECS-related work. [redacted] was interrupted by a Committee member, who requested to see a previous chart containing a plumbing diagram and asked questions regarding reactor ECS pumps and motors. Subsequent discussion of the reactor ECS design basis LOCA was primarily hardware-oriented.

Issue 2: When did DOE-SR officials learn that changes in reactor ECS limits would require a reduction in SRP reactor operating power levels?

The "Nuclear Safety Control Procedures" (NSCP) document, dated July 1984, which defined the administrative control agreements between DOE-SR and Dupont, states:

o The Technical Division, Dupont-SRL, provides independent review of issues related to reactor safety, basic technical information on reactor core design and the design of equipment and operation of processes, and maintains liaison on technical matters with DOE.

o The Reactor Safety Advisory Committee (RSAC), which is responsible for broad overview of production reactor operation and safety, provides copies of its reports to DOE-SR.

o The Reactor Department and Reactor Technology Department, Dupont-SRP, will provide daily reports to DOE-SR that include a timely description of reactor operations and related activities and problems from the viewpoint of both operating and technical groups to keep management aware of problems and developments and present pertinent facts as they are developed.

[redacted] said about August 1986, [redacted] DOE-SR, was told [redacted] that analysis of [redacted] experiments indicated ECS limits could be more restrictive than in the past and could impact reactor power limits in the winter months. In February 1987, information was provided to the RSAC concerning the ECS issue and associated experiments and the reductions in operating power levels of the SRP reactors. The perspective was the RSAC was concerned with broad, management-type issues and the ECS issue was too detailed. [redacted] said the RSAC criticized Dupont officials for not telling them of the ECS issue sooner.

[redacted] said about September 1986, [redacted] discussed a proposed project for a fourth addition to the reactor ECS [redacted] told [redacted] the fourth system was needed to gain back reactor power if the experiments led to reduced reactor power limits. [redacted] told [redacted] the ECS problem was being studied and [redacted] should contact [redacted] for information on the damage model [redacted]

[redacted] said there was no indication during July-August 1986, when [redacted] Dupont-SRL was conducting ECS-related experiments, that there was a problem with ECS limits. The fourth addition to the reactor ECS was not scheduled until 1989-1990 and the ECS issue was not mentioned in meetings with Dupont-SRL. [redacted] was told by Dupont-SRL that there were discussions between Dupont-SRL and Dupont-SRP over uncertainties in the calculations used to establish the ECS limits. [redacted] viewed this as an experimental or theoretical concern, since there was no indication of an operational concern. [redacted] next heard of the ECS issue on November 24, 1986, [redacted] told by [redacted] Dupont-SRL, that a possible change in ECS limits may affect reactor power levels in cold weather. [redacted] and should have been aware of the ECS issue, but was not. [redacted] said DOE-SR might not have been surprised in November 1986 to learn of the possible power reductions if they asked the right questions in July-August 1986. The failure of Dupont to tell DOE-SR earlier of the ECS issue was not consistent with the spirit/intent of the NSCP. [redacted] felt DOE-SR should have been told of the ECS issue when Dupont decided a fourth addition to the reactor ECS was needed. No one on the DOE-SR staff involved in reactor operations and safety tracked the ECS issue. A change in the "threshold" used by Dupont for determining when an issue should be raised to DOE-SR might have made DOE-SR aware of the issue sooner. [redacted] attended weekly meetings with Dupont-SRL personnel, but trusted them to tell of any concerns.

[redacted] DOE-SR, said [redacted] learned of the ECS issue on November 24, 1986, from [redacted] told [redacted] the results of the Dupont-SRL experiments may affect existing reactor operating power limits. This surprised [redacted] since [redacted] learned in August 1986 that Dupont-SRL was looking at the ECS issue. It was not a concern in August 1986 and did not raise a "flag". [redacted] said the ECS issue was within the guidelines of the NSCP and Dupont officials notified DOE-SR of the problem at the appropriate time. The situation regarding the ECS issue and related reactor power reduction was unique and not a violation of reactor operating specifications. [redacted] did not feel, because of existing staffing levels, that [redacted] office should have been following the ECS issue. [redacted] said on November 25, 1986, [redacted] told [redacted] there was no guarantee given the present uncertainties that reactor operations as a result of a LOCA involving the reactor ECS would be within the boundaries of the Safety Analysis Report (SAR).

[redacted] DOE-SR, said [redacted] learned of the ECS issue [redacted] on November 25, 1986. At that time, Dupont personnel had not planned to reduce power because they were trying to determine if the problem was real and were still working the data. After [redacted] on November 25, 1986, [redacted] DOE-SR, [redacted] the SRP reactor operating power levels should be reduced while Dupont continued their calculations. It was a "given" under the SAR and the DOE-SR contract with Dupont that anytime Dupont senses something is not within the boundaries of the SAR, they should "flag" it. [redacted] said in hindsight, [redacted] organization should have identified the ECS issue sooner.

[redacted] said [redacted] of the reactor ECS issue on November 24 or 25, 1986, during a meeting [redacted] They told [redacted] calculations by Dupont-SRL indicated a change in ECS limits may lead to a reduction in reactor operating power levels and preliminary numbers would be available by 4:00 PM regarding a power reduction by December 1, 1986. When [redacted] learned the preliminary number was a 20 percent power reduction, [redacted] Dupont-SRP, and recommended an appropriate reduction in reactor power levels, about 20 percent, be taken as soon as possible. [redacted] said Dupont officials should have alerted DOE-SR sooner of the ECS issue to tell them the problem was being addressed. [redacted] they did not attempt to cover up the problem. [redacted] a laboratory council the year before to keep abreast of research and development activities performed by Dupont-SRL and felt DOE-SR might have learned of the ECS-related experiments sooner if the council had been in place earlier.

[redacted] DOE-SR, said [redacted] learned of the ECS issue [redacted] on November 25 or 26, 1986. [redacted] told [redacted] knew Dupont-SRL was doing some work on ECS limits since August 1986, but had not known the details. [redacted] said in discussing the ECS issue [redacted] DOE-SR, [redacted] learned [redacted] office knew something was going on regarding the ECS issue. [redacted] office had not followed the work, which Dupont had not raised to DOE-SR as an issue.

[redacted] said [redacted] was not aware of the ECS work by Dupont-SRL until after the reactor power was reduced in late November 1986. If the ECS issue was a safety issue, [redacted] office was responsible for tracking it in the early stages. The ECS-related work was apparently evolving technically and at some point became a safety-related issue. [redacted] said in retrospect, [redacted] office should have been involved in tracking the ECS issue.

[redacted] DOE-SR, said [redacted] learned of the ECS issue [redacted] on November 26, 1986. [redacted] office stays current on Dupont-SRL activities and was aware ECS-related experiments were being conducted. [redacted] said if, in August 1986, [redacted] office had been aware of the impact of the Dupont-SRL work on the ECS and reactor power limits, [redacted] would and should have spent more time following the ECS issue. [redacted] said it "fell through the crack." [redacted] the Chairman of the DOE-SR Laboratory Overview Council (LOC), which was formally established in June 1986 to review Dupont-SRL activities. The LOC was aware Dupont-SRL was conducting experiments regarding the reactor ECS, but was not aware of their potential impact on the reactor ECS and power limits.

Issue 3: When did DOE Headquarters officials learn of the November 25, 1986, reduction in SRP reactor power levels?

Mr. Morgan said for a situation like the reduction of reactor power, he would normally contact the DOE Under Secretary's office, the DOE Office of Defense Programs (DP), and DOE-ES&H. He notified several individuals at DOE Headquarters on November 25 or 26, 1986, of the experiments and calculations regarding the reactor ECS limits and the necessity to reduce reactor power to stay within technical specifications and the SAR. He provided the information to Ms. Jo Ann S. Elferink, Executive Assistant to the Under Secretary, Mr. John L. Meinhardt, Deputy Assistant Secretary for Nuclear Materials, DOE-DP, and Mr. Grover A. Smithwick, Principal Deputy Assistant Secretary, DOE-ES&H.

[redacted] said [redacted] office had a responsibility to contact DOE Headquarters personnel regarding the reactor power reduction. [redacted] was sure they were contacted. [redacted] would have called [redacted] DOE-DP, or [redacted] but could not recall if [redacted] had.

[redacted] said [redacted] would normally contact [redacted] upon learning of something like the ECS issue and associated power reduction. [redacted] said [redacted] thought [redacted] about the problem on the same day [redacted] heard about it from [redacted]

[redacted] said [redacted] counterpart at DOE Headquarters was [redacted] DOE-ES&H. As a general rule, anything of the nature of the ECS issue/reactor power reduction would be called into DOE Headquarters, normally [redacted] as soon as possible. [redacted] said neither [redacted] notified DOE Headquarters of the problem.

[redacted] supported [redacted] statement that [redacted] contacted them on November 25, 1986, regarding the ECS issue and related reactor power reduction.

[redacted] said [redacted] was not contacted by DOE-SR in November 1986 regarding the reactor power reduction. [redacted] said [redacted] learned of the reduction in reactor power [redacted] during a staff meeting on December 1, 1986.

[redacted] said [redacted] was aware that Dupont-SRL was conducting ECS-related experiments, but did not know of any concerns related to the experiments. [redacted] was not aware the experiments were completed and what the results were until [redacted] contacted [redacted] on November 25, 1986, about the reduction in reactor power.

[redacted] said [redacted] learned of the ECS issue and related reduction in reactor power on November 26 or 27, 1986, from [redacted] DOE-DP, or [redacted] DOE-DP. Prior to that time, [redacted] had no indication there was a problem involving the reactor ECS or reactor power limits.

[redacted] said [redacted] learned of the ECS issue and related reduction in reactor power [redacted] on November 26, 1986.

[redacted] said [redacted] knew Dupont-SRL was conducting ECS related experiments, but did not know the work was leading to a reduction in reactor power levels. [redacted] learned of the ECS issue and related reduction in reactor power levels [redacted] on November 26, 1986.

[redacted] said [redacted] was not contacted by DOE-SR regarding the reduction in reactor power levels. [redacted] learned of the power reduction [redacted] shortly after it occurred.

[redacted] DOE-ES&H, said [redacted] thought [redacted] learned of the reduction in reactor power levels [redacted] during a staff meeting on December 1, 1986.

[redacted] said [redacted] learned of the ECS issue and related reduction in reactor power [redacted] on November 28, 1986. [redacted] said [redacted] would have contacted [redacted] about such an issue, but did not recall if they had.

[redacted] DOE-ES&H, said [redacted] DOE-SR on safety matters [redacted] did not learn of the reduction in reactor power levels until after it occurred.

Issue 4: Was the ECS issue identified by the NAS/NAE Committee found by a DOE-ES&H Design Review Team during their review of SRP reactors in November 1986?

The Design Review Team directed by the Office of Nuclear Safety, DOE-ES&H, conducted an on-site review of the design features of the SRP reactors during November 5-21, 1986.

The Review Team's November 1986 draft report, "Design Review of the Savannah River Production Reactors," stated:

[redacted]

[redacted] said the Review Team was concerned with the mixing of the reactor ECS flow in the reactor plenum and with the discrepancy between the computer codes and actual data from tests conducted earlier in SRP's "L" reactor. Although the Review Team was aware there was an ECS problem, [redacted] said they were not aware of its seriousness. The issue was not mentioned by the Review Team during their closeout with DOE-SR on November 21, 1986, or raised in their November 1986 draft report. [redacted] said the Review Team did not look at the same ECS problem raised by the NAS/NAE Committee, which involved individual reactor fuel assemblies. Instead, the Review Team stressed systems effects regarding the reactor as a whole. The Review Team's final report did not attempt to address the ECS issue identified by the NAS/NAE Committee. [redacted] said a discussion of the issue was included in their final report to show other events occurred since their review. [redacted] said the Department would have looked foolish releasing a report on the safety of the SRP reactors that did not include something about the ECS issue raised by NAS/NAE.

[redacted] said the Review Team did not look at the distribution of coolant in the channels of an individual reactor fuel assembly, which was the concern of the NAS/NAE Committee. They looked at flow into the reactor and the reactor plenum. [redacted] said the NAS/NAE Committee concern was more specific. They looked at one fuel assembly to determine how cooling water is distributed down the different channels.

[redacted] a member of the Review Team, said [redacted] was primarily responsible for reviewing the SRP reactor ECS. The NAS/NAE Committee and the Review Team were saying the same thing regarding the reactor ECS. [redacted] said the Review Team addressed the issue at a higher level, while the NAS/NAE Committee went into more depth. The Review Team looked at the ECS issue from a systems point of view, i.e., the affect of the reactor ECS on the reactor as a whole. The NAS/NAE Committee looked into the details and phenomena regarding individual fuel assemblies. [redacted] said regardless of the approach, the bottom line was the same. [redacted] said Dupont needed to upgrade their analytical capability for predicting reactor ECS performance as soon as possible. [redacted] was surprised that very little of the recently collected and fundamental experimental data, which should have been collected 30 years ago, had been incorporated in Dupont's analysis. Dupont officials told [redacted] November 1986 review that ECS-related experiments had been conducted and some flow distribution problems identified that might lead to a reduction in reactor power levels. [redacted] said it was only after the reactor power was reduced, several days after [redacted] visit, that [redacted] felt the ECS issue was more significant than Dupont officials had led [redacted] to believe.

Regarding the reactor ECS, the Review Team's final report "Design Review of the Savannah River Production Reactors," dated March 1987, differed from the November 1986 draft report in that it:

o Mentioned the ECS issue identified by the NAS/NAE Committee and included a longer discussion of the reactor ECS.

o Emphasized thermal-hydraulic transients and flow instabilities.

o Provided an expanded discussion of the worst case LOCA involving the reactor ECS.

o Gave higher priority to improving analytical capabilities.

Issue 5: Although asked by :

> about the results of the NAS/NAE Committee review of SRP reactors, fail to disclose a March 9, 1987, warning by the NAS/NAE Committee that "the SRP reactors were operating beyond the capacity of their cooling systems, threatening a catastrophic core melt in event of an accident"?

On February 25, 1987, Senator John Glenn, Chairman, Senate Committee on Governmental Affairs, requested testimony by the DOE Secretary or his representative at a hearing on DOE reactor safety on March 12, 1987. By letter dated March 9, 1987, the NAS/NAE Committee advised the DOE Secretary they could not conclude with confidence that significant core damage could be avoided if there was a severe LOCA while the SRP reactors were running at the current power levels.

A March 23, 1987, article in The Washington Post stated:

o During March 12, 1986, hearings by the Governmental Affairs Committee on reactor safety, DOE officials testified the Savannah River safety design was "fundamentally sound".

o

o The NAS panel warned the DOE Secretary the SRP reactors were operating beyond the capacity of their cooling systems, threatening a catastrophic core melt in the event of an accident.

[redacted] said [redacted] the March 9, 1987, NAS/NAE letter [redacted] on March 10, 1987, the same day it was received by DOE-ES&H. [redacted] said [redacted] was in coordination on March 10 and 11, 1987. [redacted] did not think the NAS/NAE letter had been evaluated in time to be included.

[redacted]

[redacted] stated a design review of the SRP reactors concluded that while the designs are fundamentally sound, a number of enhancements are desirable.

[redacted] regarding the results of reviews of DOE reactors by NAS were in regard to the Department's "N" reactor at Hanford, Washington. The transcript did not include a statement by DOE officials that the Savannah River safety design was "fundamentally sound."

DOE/RL 87-05

N REACTOR SAFETY ENHANCEMENT PROGRAM

SUMMARY DESCRIPTION

April 1987

U.S. Department of Energy
Richland Operations Office

N REACTOR SAFETY ENHANCEMENT PROGRAM

TABLE OF CONTENTS

Page

1.0 INTRODUCTION. 1
1.1 Chernobyl Accident Background 2
1.2 N Reactor Location and Description. 4
1.3 Chronology of Recent N Reactor Safety Reviews 5
2.0 PLANT MODIFICATIONS 9
2.1 Control Room Habitability 9
2.2 Emergency Core Cooling System Upgrade 10
2.3 Remote Reactor Shutdown Capability 12
2.4 Emergency Control and Operational Support Center Upgrades . 12
2.5 Hydrogen Monitoring and Mitigation. 14
2.6 Plant Emergency Warning/Annunciation Upgrade. 16
2.7 Liquid Effluent Retention Facility 16
3.0 TECHNICAL STUDIES/EVALUATIONS 18
3.1 Confinement System Testing. 18
3.2 Pressure Tube and Graphite Analysis 20
3.3 Equipment Qualification 22
3.4 Probabilistic Risk Assessment 23
3.5 Analysis of the Hypothetical Accident 26
3.6 Hydrogen Evolution Analysis 26
3.7 Evaluation of Forms and Quantities of Iodine. 26
3.8 ECCS Seismic/Wind Studies 27
4.0 MANAGEMENT SYSTEMS AND TRAINING IMPROVEMENTS. 28
4.1 Management Systems. 28
4.2 Training. 29
5.0 CONCLUSION. 31
APPENDIX - DEFINITIONS 32

1.0 INTRODUCTION

This report is a summary description of the Safety Enhancement Program (SEP) established by the Department of Energy (DOE) for N Reactor, located on the DOE's Hanford Reservation in Washington State.

Following the accident at the Chernobyl Nuclear Power Plant in the Soviet Union, safety reviews of N Reactor were accelerated and expanded, at the request of the Secretary of Energy, to include reviews by independent consultants as well as internal DOE reviews of the safety of operation of N Reactor. These safety reviews have produced recommendations that address the reduction of the probability of accidents and that provide increased assurance that outcomes from potential accidents are minimized with regard to the health and safety of workers and the public. The collection of activities that address these safety-related recommendations made during the above safety reviews constitutes the N Reactor Safety Enhancement Program.

The independent consultant reports and DOE internal reviews found that the same accident which occurred at Chernobyl is not possible at N Reactor. Notwithstanding this fact and the overall conclusion of these assessments that N Reactor does not pose an unacceptable risk to workers or the public*, the need for concerted action on the recommended design and operational improvements is recognized. With an objective to achieve even greater margins of safety, DOE has developed the N Reactor Safety Enhancement Program to assure that all appropriate improvements are accomplished.

At the conclusion of the N Reactor safety reviews, DOE, in exercising an abundance of caution, decided to place the reactor in a standdown condition at the next scheduled outage for refueling and maintenance. This was designed so that planned safety improvements could be performed in a more efficient and timely manner. Reactor "standdown" was initiated even though DOE had concluded that continued operation of N Reactor does not present an unacceptable level of risk to workers or the public. It is presently planned that the N Reactor will be operated at reduced power until the planned hydrogen mitigation equipment is operational to preclude fuel melting and hydrogen generation. The Department has advised the National Academy of Sciences of the Department's plans regarding hydrogen mitigation and continued operation of the reactor, and requested that the National Academy of Sciences specifically provide input on this subject.

*Two of the six independent consultants recommended that continued operation be predicated on the essential need for N Reactor in terms of national security. The DOE Under Secretary reaffirmed this need in a December 12, 1986, statement.

The following sections of this Introduction provide background information on N Reactor, results of recent safety reviews and discussion of the implementation of the Safety Enhancement Program. Sections 2.0, 3.0, and 4.0 of this document summarize the specific N Reactor SEP modifications, special technical studies and evaluations, and improvements in management systems and personnel training being implemented to further increase the margin of safety at N Reactor. It is noted that the changes will comply with DOE Orders and will be in accordance with uniform standards, guides, and codes which are consistent with those applied to comparable licensed reactors.

1.1 Chernobyl Accident Background

The N Reactor Safety Enhancement Program was developed to respond to findings of safety reviews performed by, or at the request of, DOE following the accident at Chernobyl. All of the internal and external safety reviews of N Reactor concluded that the same accident that occurred at Chernobyl can not occur at N Reactor due to a fundamental and critical design difference (see Section 1.3). Of key importance to this conclusion was that the Chernobyl reactor had a positive coolant void reactivity coefficient under certain operating conditions, while N Reactor (and other U.S. reactors) has a negative coolant void reactivity coefficient under all conditions. A positive coolant void reactivity coefficient means that when steam forms in the reactor, reactor power level increases, while a negative coefficient means the opposite (reactor power decreases).

Other analyses performed for the Department of Energy by a team of technical experts from the national laboratories (published as DOE/NE-0076, November 1986) concluded that the causes of the Chernobyl accident were as follows:

- The Chernobyl plant was placed in such an unstable condition that any event that resulted in a significant increase in the amount of steam in the reactor would have resulted in a damaging reactor power level increase called a "power excursion."

- The DOE expert team's analyses have confirmed the Soviet's claim that a reactivity excursion occurred and was caused primarily by increased steam formation due to overheating in the reactor when the coolant flow was reduced.

- The power excursion probably peaked significantly above 350,000 megawatts thermal (MWt), which is 100 times the normal full power of the Chernobyl plant.

- When the fuel failed as a result of the power excursion, a fraction of the fuel was forcibly ejected into the coolant causing extremely rapid formation of additional steam. This steam explosion destroyed the Chernobyl reactor.

- Improper operator actions at Chernobyl, which involved disabling key safety systems, failure to follow procedures, and failure to have independent safety review of procedure changes, combined with the reactor instabilities (i.e., the positive coolant void reactivity coefficient) to allow the steam explosion to occur.

There was early conjecture that the Chernobyl accident was caused by or exacerbated by graphite burning and a zircaloy-water reaction that produced hydrogen causing a hydrogen explosion. There is no evidence that these phenomena had any significant impact on the consequences of the Chernobyl accident.

The detailed understanding of the accident provided by the DOE expert team's analyses resulted in an assessment of the potential for a Chernobyl type accident in the U.S. reactors. The expert team found that U.S. reactors are designed such that a large power excursion due to core instability from a positive coolant void reactivity coefficient is not possible. In addition, there are a number of basic design differences between the Chernobyl reactor and N Reactor that make their response to operating and emergency conditions markedly different. N Reactor's operating and emergency responses do not lead to the instability that the Chernobyl plant experienced. Significant differences include the following:

o N Reactor's control rods are used to control the nuclear reaction and shut the reactor down if necessary. N Reactor control rods are fully inserted in 1.5 seconds. The Chernobyl reactor required 20 seconds for full insertion.

o As a back-up to the control rod system, N Reactor has an independent, fully automatic, fail-safe backup shutdown system. This system will shut down the reactor within two seconds and does not require electrical power to operate. The Chernobyl Reactor had no fast-acting backup shutdown system.

o N Reactor has a negative coolant void reactivity coefficient for all of its operating range; therefore, the reactor power level will decrease should loss of cooling water or steam formation occur. The Chernobyl reactor was designed to have a positive coolant void reactivity coefficient; that is, if the amount of steam is increased in the reactor coolant, an increase in power level occurs. Furthermore, N Reactor coolant does not form steam in the reactor under normal operating conditions.

o The confinement system at N Reactor encloses the entire reactor and primary coolant piping. The Chernobyl confinement enclosed only the primary coolant piping. The top of the reactor core was not enclosed in the Chernobyl confinement structure.

Notwithstanding the absence of relevant similarities between N Reactor and Chernobyl, in accordance with its stated objective of pursuing safety excellence, the Department of Energy developed a Safety Enhancement Program to respond to the reviewers' recommendations and to obtain the greatest possible safety margins at N Reactor.

1.2 N Reactor Location and Description

The N Reactor is located in the north central part of DOE's Hanford Site in southeastern Washington State. The Hanford Site comprises some 570 square miles of semi-arid land. Cooling water for N Reactor comes from the Columbia River, which flows through the northern and northeastern part of the site.

There are no residences on the Hanford Reservation. The nearest inhabited residences are farm houses six miles northwest of the N Reactor. There are 35 residences within a ten mile radius of the N Reactor site, which is the normal emergency planning zone distance for commercial nuclear reactors.

N Reactor facilities occupy a 90-acre site on the southeast bank of the Columbia River within a 5 1/2 mile exclusion area. The Washington Public Power Supply System (Supply System) Hanford Generating Project, which uses by-product N Reactor steam to generate electricity, is located immediately adjacent to the N Reactor complex.

N Reactor fuel is slightly-enriched uranium, and the reactor itself is a pressure-tube type, light-water cooled, graphite-moderated reactor designed and operated to produce special nuclear materials at a power level of approximately 4,000 megawatts thermal (MWt). The excess steam produced by the plant is used to produce electrical power at the adjacent Hanford Generating Plant. The reactor core is a 1,800-ton graphite block approximately 33 feet by 33 feet and 39 feet long. A total of 1003 horizontal pressure tubes extend through the core. Perpendicular to the pressure tubes are 84 boron-carbide horizontal control rods which provide the neutron control, and the primary safety shutdown mechanism. Independent backup safety shutdown control is provided by the neutron absorbing ball safety system. The horizontal control rods and the ball safety systems were designed with sufficient speed to prevent fuel damage due to overheating and to keep the reactor in a safe shutdown condition.

In addition to the control and reactor shutdown systems, there are inherent safety features as part of the core design to prevent accidental excursions and to mitigate accident consequences in the event of an excursion-type accident.

A thermal shield surrounds the graphite moderator to intercept the radiation and heat energy that escapes from the reactor core. The thermal shield is surrounded by a biological shield which prevents the radiation activation of equipment in areas where operating personnel may be required for maintenance activities.

Because of the N Reactor design and the site location, safety analyses conclude that N Reactor conforms to Title 10, Code of Federal Regulations, Part 100 (10 CFR 100) guidelines using a confinement system rather than a containment-type system used in commercial light water reactors. The confinement system is designed to release the initial steam produced by a rapid loss of coolant pressure such as that which could be produced by a coolant pipe break. Because N Reactor is not allowed to operate with failed fuel, this steam contains only an inconsequential quantity of radioactivity. When the confinement pressure subsides, the steam vent valves close and the exhaust valves open to ventilate the reactor building through a set of high efficiency filters. This will establish a filtered release path prior to the release of fission products in the unlikely event that a fuel element failure occurs.

If a primary coolant pipe break should occur, N Reactor has an Emergency Core Cooling System (ECCS) to provide a separate, independent water supply for emergency once-through cooling of the reactor. The ECCS is intended for use only if the normal recirculating water heat removal system is disabled by a major break in the reactor coolant system piping. The ECCS is designed to prevent fuel failures in the unlikely event of major pipe breaks.

N Reactor also has a unique third level cooling system, called the graphite and shield cooling system. This system aids in cooling the graphite during normal operation; most of the heat is removed by the primary coolant. In the unlikely event of a major pipe break and a total failure of the ECCS, this system alone is sufficient to limit core melt and subsequent fission product release to below the safety guidelines presented in 10 CFR 100.

1.3 Chronology of the Recent N Reactor Safety Reviews

Following the Chernobyl Reactor accident, new safety reviews of N Reactor were undertaken at the request of the Secretary of Energy and planned safety reviews were accelerated and expanded. Three safety reviews were conducted under the direction of the DOE's Assistant Secretary for Environment, Safety and Health. Independent reviews were also conducted by the General Accounting Office (GAO), a group appointed by former Governor Atiyeh of Oregon, six expert consultants (the Roddis Panel) commissioned by the Secretary of Energy, and lastly, the National Academy of Sciences (NAS) and the National Academy of Engineering (NAE). In the past year, N Reactor has been examined by seven safety reviews comprised of 51 expert reviewers.

A chronology of the safety reviews and subsequent reports follows:

- In May 1986, at the request of the Secretary of Energy, a Special Safety Review Team, convened by DOE's Assistant Secretary for Environment, Safety and Health (ASEH), conducted evaluations of the fire protection systems for the graphite moderator and of the safety of the N Reactor confinement system. Results of this review are included in a report released in May 1986, "Report of the Special Safety Team Review of N Reactor (Graphite and Confinement Issues)."

o A DOE Technical Safety Appraisal of N Reactor, one of a series of such reviews of DOE facilities being performed under order of the Secretary of Energy, was conducted under the authority of the ASEH between May 1986 and June 1986. This Technical Safety Appraisal was a multi-disciplined review covering all aspects of the operation of N Reactor. Results of this review were documented in DOE/EH-015, "Technical Safety Appraisal of the N Reactor, June 1986."

o From May 1986 through July 1986, a Design Review of N Reactor was conducted by a DOE team of experts at the request of the Secretary of Energy. This review, performed under authority of the ASEH, examined the plant systems that are the most important in preventing release of radioactive materials in the event of major equipment failures and/or human error. The results of this review are documented in DOE/EH-017, "Design Review of the N Reactor," dated September 1986.

o A committee from the GAO visited N Reactor in June 1986. Representatives from the Oregon Department of Energy also participated in this visit. The GAO issued its report in August 1986, (GAO/RCED-86-213BRC). The state of Oregon Appraisal Report was also issued in August 1986.

o In May 1986, the Secretary of Energy appointed six individual consultants to "assist the Department by ensuring that we have examined all of the key technical questions and probed into the safety issues raised by the Chernobyl Accident" as they may relate to N Reactor. Each consultant provided an individual report which was released by DOE in December, 1986.

o The Secretary of Energy requested that the National Academy of Sciences (NAS) and the National Academy of Engineering (NAE) make an independent safety assessment of DOE's major production and research reactors including N Reactor. These reviews began in December 1986, and the recommendations will be incorporated into the SEP when made available by the NAS/NAE.

Based upon and following evaluation of the available reports and recommendations of the above N Reactor Appraisal Teams, the DOE concluded that the N Reactor does not pose an unacceptable risk for continued operation, and it could not have the same accident that occurred at Chernobyl. DOE decided that actions could and should be taken on the recommendations to further enhance the N Reactor's margin of safety.

On December 12, 1986, DOE announced its decision for standing down N Reactor by extending the refueling and maintenance periods scheduled to start on January 7, 1987, and provided additional funding to accelerate completion of many of the recommended actions ahead of the previously defined schedule.

This Safety Enhancement Program responds to the recommendations of the appraisers regarding the prevention of accidents and mitigation of their consequences. Recommendations dealing with normal N Reactor maintenance and operation that do not directly affect reactor safety are not a part of the Safety Enhancement Program. The responses to all recommendations are being tracked by DOE with detailed programmatic documentation which assures adequate response to each of the comments.

Recommendations addressing overall DOE policy issues that are relevant to DOE-wide reactor safety are being addressed by the Department's Office of Environment, Safety and Health directly. These include recommendations made by the six individual consultants that greater use be made by DOE of the Advisory Committee on Reactor Safeguards (ACRS) and the Institute of Nuclear Power Operations (INPO). Other concerns raised by the consultants included the assignment of organizational safety responsibilities within DOE, the need for a standing safety oversight group, and a comparability with commercial licensed reactor practice. The continuing need to combat institutional complacency, a recommendation of several independent consultants, is being addressed both through consideration of expanded external reviews (e.g., ACRS or INPO) and personnel training described in the SEP for N Reactor. As noted by the Under Secretary in his December 12, 1986, statement on the planned standdown, these and other policy issues are under review by the Department and a course of action will be decided once the results of the NAS/NAE review are available to DOE. Because of their DOE-wide signficance, these broad policy issues are not addressed in the N Reactor SEP.

The Safety Enhancement actions presently being taken are grouped into three broad areas affecting reactor safety, with emphasis on prevention of serious reactor accidents and their mitigation. These areas are:

1. Plant modifications designed to improve the ability of plant safety systems to prevent or mitigate serious reactor accidents (Report Section 2.0).

2. Technical studies and evaluations of reactor performance to understand more completely the mechanisms by which low-probability accidents might occur. The results of these studies may possibly result in recommendations for additional plant modifications (Report Section 3.0).

3. Personnel training and administrative changes to provide both heightened awareness and enhanced responses to severe and extremely low probability reactor accidents. (Report Section 4.0.).

2.0 PLANT MODIFICATIONS

The N Reactor Safety Enhancement Program includes the seven plant modifications discussed in the following sections that have been accelerated to further enhance N Reactor safety margins. Most of these enhancements were previously planned in the ongoing comprehensive N Reactor safety program. All of the modifications are designed either to further decrease the already low probability of accidents, or to further reduce the consequences of such events should they occur.

2.1 Control Room Habitability

The primary reactor control center (room) is continuously staffed by certified operators trained to monitor instrumentation, make routine adjustments to plant operating processes, and be prepared to back up automatic safety features by taking decisive actions in the event of an accident.

Currently, the N Reactor control room ventilation system uses outside air that is filtered and either heated or cooled by a single air handling unit before being routed through ducts into the control room. Air from the control room is then exhausted into the electrical relay room beneath the control room through floor-mounted exhaust fans. Most of the air reaching the relay room is returned to the air handling unit through a ceiling damper. The remaining air is exhausted through an electrical switchgear room. Isolation of control room ventilation, if necessary, would be accomplished by automatic closure of the outside air inlet and exhaust dampers, manual shutdown of the exhaust fans, and recirculation of the control room air by the same air handling unit through the pathways described.

The upgrades to the N Reactor control room will provide protection for up to ten control room operators for seven days in the event of a low-probability accident. Such an unlikely event might involve natural phenomena such as earthquakes, tornadoes and volcanic eruptions, and the release of airborne radioactive materials and water treatment chemicals (e.g., chlorine and ammonia). Although the air within the control room could be recirculated and filtered, since the existing control room air pressure is not higher than that of surrounding areas, the breathing air could become contaminated by released radionuclides or chemicals. The control systems will automatically shut down the reactor in the event of an accident and, if necessary, will automatically initiate engineered safety features to prevent or limit any fuel damage. Cooling systems are designed to cool the reactor without any operator action for a minimum of seven days. However, safety could be enhanced by allowing operators to remain in the control room for monitoring and adjustments. Although the operators currently could remain in the control room by using available self-contained breathing apparatus in the event of a serious accident, it was decided that the control room habitability should be enhanced. This 1985 project is being expedited under the SEP, and construction will be completed in December 1988.

The N Reactor control room habitability upgrade will provide an air handling system with dual emergency air intakes (one local and one remote intake), high efficiency in-line filtration and sufficient capacity to pressurize the control room to prevent inleakage of contaminated air. The new ventilation system will be used solely for the control room. Both radiation and chemical gas monitors, together with high efficiency filters, will be provided on the emergency and normal air intakes. In the event of an accident or material release, automatic isolation of the normal control room air intake and realignment of the ventilation system will occur by means of a new damper arrangement. Electrical power for ventilation system operation will be provided by the two existing independent power sources. Should these power sources fail, the ventilation system would automatically receive power from a new on-site emergency diesel generator dedicated for this purpose. All emergency ventilation system components and other components required for control room habitability will be constructed to meet seismic and tornado protection requirements. The control room structure will also be upgraded to provide increased tornado missile protection and additional radiation shielding. Control room operators will also be provided with supplies adequate to serve up to ten people for seven days. These supplies will be seismically secured and stored within the existing control room or in accessible seismic- and tornado-protected rooms.

2.2 Emergency Core Cooling System (ECCS) Upgrade

This section describes the planned safety enhancements of the N Reactor Emergency Core Cooling System which increase the water supply capabilities and add to the existing pumping system's redundancy.

2.2.1 Increasing Water Sources and Pumping Capabilities

The N Reactor ECCS is a once-through reactor cooling system. The ECCS is an engineered safety system designed to ensure adequate fuel coolant for any reasonably conceivable event. It draws water first from the plant's water storage tanks, and then, if necessary, directly from the Columbia River. The system will start automatically in the event of a loss of normal cooling water and will not require operator attention for seven days of operation.

The existing ECCS uses two stages of multiple, redundant, direct-drive, diesel-powered pumps that force the cooling water through the reactor. The system has sufficient redundancy to allow for active component (pump) failures. The ECCS is tested routinely and rigorously. It has not been necessary to utilize this system since the initial startup of N Reactor in 1964.

However, DOE is increasing the redundancy and reliability of the ECCS System. The planned ECCS water source and pumping capability enhancements would provide a second fully independent ECCS. This plan includes construction of a new water storage tank close to the reactor and a connection to 50 million gallons of water stored in two existing basins 6.5 miles from N Reactor. Another direct-drive, diesel-powered pump and fuel supply will be added to ensure delivery of the water to the ECCS piping. This water storage and pump addition will be sized to meet the cooling requirements of the reactor in the event of concurrent failure of both the normal cooling water system and the current ECCS.

Following reactor cooldown, the water needed to maintain cooling would be provided by an independent water supply that would be tied into the ECCS. This water would be pumped from either of two existing 25-million gallon storage basins. These two basins are currently fed from the Columbia River by electric motor-driven pumps, and one of the two is backed up by direct-drive diesel-powered pumps. Thus, the new system, comprised of stored water at 100-N Area and the 50-million gallons in tanks away from N Area, will provide both independent water source availability and pumping redundancy for reliable reactor core cooling in the extremely low probability event of a failure of the current ECCS water supply system. Design of the tie-in to the two 25-million gallon basins is underway and construction is scheduled for completion by November 1987. Construction of the new water tanks and pumps is scheduled for completion in May 1991.

2.2.2 Enhanced Separation of ECCS Components

The existing N Reactor ECCS has two groups of diesel-driven pumps operating in series to provide emergency cooling water. The first pump group, the low-lift diesels, takes water from the Columbia River and supplies it to the second pump group, the high-lift diesels, for injection into the supply side of the reactor coolant system.

Fire protection for the diesels is provided by water spray systems which operate automatically upon heat detection to deluge simultaneously all engines in the same pump group. Water spray on the diesel engines would not stop engine operation. One diesel engine in each pump group is currently separated from nearby engines by a concrete block wall. The other diesel engines in each pump group are separated by corrugated metal barriers. Since the start of plant operation in 1964, there have been no fires involving these components.

Engine control and performance with the existing configuration of electrical control circuits have been very reliable. However, the electrical control circuits for the high-lift diesels are close together inside the building where they are housed.

Design changes are underway to provide enhanced separation and fire protection for the ECCS components. Higher, wider fire resistant walls will be built to physically separate the adjacent engines at both pumping stations. Master control valves in the existing deluge water spray system will be replaced with an individual valve and an automatic detection system for each engine's spray nozzle array. This independent protection feature will eliminate the possibility of drenching units other than the one that might be affected. The physical separation of electrical control circuits for the engines will be enhanced to better meet the current nuclear safety standards of the Institute of Electrical and Electronic Engineers (IEEE) for separation and isolation. The changes include circuit waterproofing. Construction will be completed by July 1, 1987.

2.3 Remote Reactor Shutdown Capability

A remote reactor shutdown control capability now being installed will provide the operating staff with the capability to shutdown the reactor independently from the control room, as well as to provide the ability to monitor critical plant systems and to verify the shutdown status. The panel operator will be capable of both rapid shutdown of the reactor and activating the ball safety system in a single operation. The ECCS supply and exit valves will also be activated by a single operation.

Suitable space within the N Reactor building, but remote from the current control room that meets all the required environmental, seismic, and security requirements for the remote shutdown panel has been identified. Heating and cooling of the room are provided by the existing building ventilation system, and a Halon 1301 fire protection system is installed. Access to the room will be limited to authorized personnel who will be monitored by site security for admission. A dedicated communication system will be provided with direct lines to the emergency response facilities (see Section 2.4), the existing control room, pump houses, and the standby power house.

Electrical power sources for the remote shutdown room will be independent from the control room power sources and will be of equal reliability to the normal control room power sources. The control circuits are routed from locations outside of the control and electrical relay rooms where possible.

The control circuits that do route through the control or electrical relay rooms are designed to be fail safe. The system has been designed and qualified such that equipment failure in the remote shutdown room will not prevent normal control room functions. Qualification of all control circuit components will comply with IEEE standards. This modification is scheduled to be complete and fully operational by July 1, 1987.

2.4 Emergency Control and Operational Support Center Upgrades

In the event that an accident occurs at N Reactor or appears imminent, three additional emergency response facilities which would supplement the existing emergency support facilities are planned: 1) the Emergency Control Center (ECC), 2) the Technical Support Center (TSC), and 3) the Operational Support Center (OSC).

In order to be consistent with the emergency preparedness standards for commercial nuclear reactors, the ECC and TSC require radiological protection for continuous habitability during severe accidents, along with adequate communication links and other required emergency equipment and supplies. The OSC, on the other hand, does not require radiological shielding and specially filtered breathing air protection, but does require modern communication links with the control room and the TSC, surplus supplies such as plant diagrams, emergency procedures, manuals, self-reading dosimeters, and other provisions to enable the staff to better manage a serious accident.

2.4.1 Technical Support Center (TSC)

The TSC is an emergency facility where predesignated technical, engineering, and plant management representatives assemble for the purpose of providing the additional management and technical expertise required to prevent an accident or to minimize its consequences. This location must meet the same habitability requirements as the control room. A dose assessment computer and direct lines from the TSC to the OSC and ECC will be added. Other required upgrades are included as part of the control room habitability project (see Section 2.1 above). The TSC will be completed by December of 1988.

2.4.2 Emergency Control Center (ECC)

The ECC is a facility remote from the N Reactor site that will be used for overall management of emergency response, including coordination with the DOE's Richland Operations Office. Its habitability requirements are similar to those of the TSC. A recently (1982) decommissioned, underground, DOE-owned emergency command center has been reactivated as the N Reactor ECC.

By July 1, 1987, enhanced voice and data communications plus habitability improvements for the ECC will be completed. An emergency diesel generator will be operable by September 30, 1987.

2.4.3 Operational Support Center (OSC)

Should an accident occur, teams composed of plant craftsmen, operators, and radiation technicians would man the Operational Support Center facility and take coordinated actions to prevent or minimize the consequences of such an event before fission product release begins.

The area selected for the OSC is the recently-completed N Reactor outage center. This location is ideally suited for an OSC since it provides comprehensive communications within the N Reactor facility and is in close proximity to the reactor control room. No additional construction or modification was required to establish the OSC. Administrative controls, procedures, and communications links are being finalized, and the OSC will fully operational on July 1, 1987.

2.5 Hydrogen Monitoring and Mitigation

One of the concerns during the Three Mile Island (TMI) accident was hydrogen gas generation within the containment. At N Reactor, no hydrogen generation could occur unless a loss of coolant accident occurs, the ECCS fails to operate, and then cooler water is introduced to the hot reactor core. Consequently, the simultaneous occurrence of several unlikely events would be required for any hydrogen to be generated.

The 1978 N Reactor Updated Safety Analysis Report (NUSAR) analyzed the consequences of hydrogen release to the confinement system. The NUSAR analysis concludes that the hydrogen releases to confinement, if adequately mixed, would not reach the lower hydrogen flammability limit because of the large N Reactor confinement volume and the continuous filtered release operating mode. This has been confirmed by more recent analyses. However, the SEP will provide added margin against hydrogen accumulation, with plant modifications to provide equipment to monitor for hydrogen and prevent flammable mixtures of hydrogen and oxygen. The following two sections address current plans to achieve the hydrogen monitoring and mitigation capability.

2.5.1 Hydrogen Monitoring

If any hydrogen were to be generated, it could accumulate only in confined spaces. These spaces will be monitored for hydrogen and oxygen. To provide adequate coverage for confined spaces and the balance of confinement, hydrogen monitoring equipment is being installed in the following areas:

- front and rear face reactor spaces
- pipe gallery space
- space surrounding the primary coolant pressurizer
- six steam generator cell spaces.

Twenty sampling points in the above named spaces will be used for redundancy. This monitoring system will remotely measure the concentrations of hydrogen and oxygen at each of these locations. The system will be used by reactor operators to evaluate the presence of hydrogen and the effectiveness of mitigation actions. While this system would not be required for the accidents analyzed in the safety analysis report, it would provide additional monitoring capability for unforeseen events.

The monitoring device being considered for use at N Reactor meets current commercial standards. It provides real-time monitoring for both hydrogen and oxygen. The hydrogen and oxygen sampling/monitoring system is currently under construction and will be operational by July 1, 1987. The system will employ two identical and redundant monitoring systems. The monitoring systems will draw samples from each of the designated confinement system volumes, analyze for hydrogen and oxygen, and exhaust the sample air back into confinement. The monitoring data will be displayed in the N Reactor control room. All controls needed to operate the system will be accessible from the control room. System components will be fully qualified to function in the temperature, pressure, and radiological conditions projected for the hypothetical accident. In addition, the system will be seismically designed to ensure function following an earthquake.

2.5.2 Hydrogen Mitigation

The purpose of the hydrogen mitigation system is to prevent the occurrence of flammable gaseous mixtures of hydrogen and oxygen. Several alternative mitigation concepts have been or are currently being evaluated. These include the following: 1) either pre- or post-accident purging of the containment atmosphere and replacement with nitrogen, an inert gas, with or without controlled venting and filtration, 2) forced mixing of air between the reactor building and steam generator building, 3) controlled burning by use of ignitors, and 4) recombining hydrogen with oxygen by means of thermal, flame, or catalytic devices.

Although the study of all alternatives is not completed, a combination of forced mixing, controlled exhausting, and post-event nitrogen purge/inert currently appears to be the most promising concept. Forced mixing between the reactor building and the steam generator building atmospheres would reduce the possibility of local accumulations of hydrogen. A controlled, filtered exhaust would maintain the pressure in the confinement system below that of the outside atmosphere and would vent the hydrogen through charcoal and high efficiency filters from the building. Post-event nitrogen purging could provide an additional margin of safety by guarding against long-term hydrogen accumulation in confinement.

Installation of the hydrogen mitigation system is scheduled for completion by December 1987.

2.6 Plant Emergency Warning/Annunciation Upgrade

Rapid alarm annunciation and/or voice communications at the onset of abnormal or postulated emergency events can be important both to alert plant personnel to possible hazardous conditions and to assemble and dispatch the operating and maintenance staffs to correct the conditions that could lead to hazardous events. N Reactor, like most commercial nuclear power reactors, has six ways to alert workers to such events: 1) local zone radiation alarms, 2) local area/building fire alarms, 3) plant-wide evacuation alarms, 4) a public address system, 5) paging devices, and 6) emergency accountability procedures that provide verification that all personnel are accounted for and are aware of any real or potential emergency.

System enhancements were identified as increased area coverage by evacuation alarms, local fire alarms, and the public address system. An in-depth evaluation of these three systems was conducted by the N Reactor staff. Enhancement actions have been defined, implemented, or are planned. All enhancements will be completed by July 1, 1987.

2.7 Liquid Effluent Retention Facility (LERF)

Although N Reactor currently complies with DOE and comparable NRC Reactor Site Criteria (10 CFR 100) with respect to population doses that could result from a postulated major accident, it is the intent of this enhancement to increase safety margins by making improvements to N Reactor's emergency liquid retention basin.

An emergency retention basin is utilized to receive the radioactive liquid effluent in the event of an accident.

Under the Safety Enhancement Program, the existing emergency retention basin capacity will be increased from 5.5 million gallons to 11.2 million gallons. The basin will be double-lined to enhance protection against potential radionuclide migration into the groundwater, and it will also be provided with a cover to minimize release of radioiodine to the atmosphere. A leak detection and collection system will be installed to monitor liner integrity. Provisions will also be established to provide an annual inspection of the cover. These modifications are designed to contain about 95% of the liquid-borne radioiodine anticipated to be released during a low-probability accident.

Upon detection of accident conditions, flow of radioactive emergency cooling water will be automatically delivered to the new lined liquid effluent retention facility. When the capacity of this lined retention basin is reached, passive initiation of flow to the normal waste disposal facility via a newly-constructed bypass will occur. This bypass will only be used following retention of the accident waste within the lined basin.

New valves, including those required to isolate the system for maintenance, will be installed in existing lines to direct flow into the lined retention basin upon ECCS actuation. Annunciation will be provided in the N Reactor Control Room for valve operation, low temperature warning (for freeze protection), and low pressure warning (valve actuating devices). Indications to show water level in the lined retention basin will also be provided. Control room remote operation and local operation of the valves will also be provided.

Groundwater monitoring wells will be installed on the river side of the retention lined basin to monitor radionuclides in the groundwater should an accidental release occur and the basin malfunction.

Mobile waste treatment equipment would be used for cleanup of retained liquid in the lined basin. This upgrade is scheduled to be completed by July 1, 1987.

3.0 TECHNICAL STUDIES/EVALUATIONS

This section describes technical studies and evaluations currently being conducted as part of the N Reactor SEP.

3.1 Confinement System Testing

N Reactor's confinement system was designed to prevent overpressurization during an accident and confine fission products inside the reactor building in the unlikely event of massive fuel failure. Following a low-probability major coolant pipe break, steam released from the reactor coolant system is vented to atmosphere through normally open steam vent valves that are sealed for normal operations with weather caps. Calculated maximum confinement pressure is about 4.2 psig. Automatic fog sprays actuate to condense the steam, further reducing the pressure. In this way the confinement pressure would rapidly decrease to a pressure slightly above atmospheric. The large vent valves would close and the fog sprays would continue to cool the resealed confinement. The sequence is fast enough to reseal the confinement before any fission products are released from the fuel.

In the hypothetical case in which the emergency cooling system also fails, uranium fuel would heat up, fuel cladding failures would occur and fission products could be released to the confinement system. The already resealed confinement system would be operating at a slightly positive pressure. Releases of radioactivity to atmosphere would occur through the activated charcoal and high-efficiency particulate air filters. The filters significantly reduce the quantity of the fission products released. This system improves public protection by keeping dose commitments from such accidents below that required by DOE requirements and comparable Nuclear Regulatory Commission standards for commercial light water reactors.

The concrete confinement structure contains sealed penetrations through which piping and electrical leads pass. The N Reactor confinement system is designed to operate in such a way that confinement penetrations would not be subjected to high pressures when fission products are present. Included in this task is testing of confinement components at pressures somewhat higher than atmospheric to assure their ability to subsequently maintain sealing capabilities upon fission product release into the confinement. Enhanced tests, and other related studies described below, have been established to further ensure that the confinement system will operate as designed or better. Completion of the six identified tasks is scheduled by July 1987, including any modifications to the system that might be determined to be appropriate.

3.1.1 Test Confinement Seals

This task will pressure test a statistically based number of confinement system penetrations. The sample penetrations will be subjected to the maximum calculated blowdown pressure; this test will be preceded and followed by a low-pressure leak test. This will demonstrate that the penetration seals are not compromised by peak confinement pressures. The test will verify the confinement penetration integrity at the low pressures during which fission products are released. All penetrations not tested in the original sampling will be tested over a period of several years.

3.1.2 Test Confinement at Higher Pressure

Integrated leak rate testing of the N Reactor confinement has been routinely conducted somewhat above the filtered release mode pressure. Higher pressure testing of the confinement system will be conducted to provide enhanced assurance that design requirements will still be met following exposure to pressures typical of a serious accident. The response of the confinement system instrumentation will be monitored to verify proper response of subsystems and instruments. The impact of the test pressure cycle on the filtered release leak rate will be determined by conducting a low pressure leak test both immediately before and after the pressure transient is applied. This test will also be based on Nuclear Regulatory Commission standards.

3.1.3 Protect Steam Vent Valves From Debris

The susceptibility of the N Reactor confinement steam vent valves (which vent high pressure steam from postulated pipe break) to blockage from the potential effects of debris will be evaluated.

Analyses using current methodology will provide velocity profiles for the steam during low-probability accidents. The analyses will determine the potential for the steam to carry debris into the steam vents and the resulting potential impacts on the designed operation of the valves. Should any potential impacts on the operation of the valves be found, they will be scheduled for corrective action based on a risk assessment of the consequences.

An earlier investigation revealed the need to strengthen a cable tray in close proximity to a steam vent valve opening. This task will also ensure satisfactory completion of the cable tray structural upgrade.

3.1.4 Ensure Sensing Line Block Valve Lineup and Control

The confinement sequence (fog spray actuation, steam vent valve closure, heating and ventilation shutdown, etc.) is initiated by increased pressure within the confinement. Sensing lines from various confinement locations are routed to pressure switches located outside of the confinement. A block valve is provided between the switch and the open sensing line to permit periodic calibration of the switches as required by technical specifications. More stringent control requirements will be established to ensure proper lineup and control of the block valves because of their critical importance to confinement system operability. The existing controls will then be compared to the requirements. Should any discrepancies be found, they will be corrected by plant modifications and/or administrative system upgrades.

3.1.5 Determine Hydrogen Iodide Decontamination Factor

Efficiency testing of the N-Reactor confinement system halogen adsorbers does not presently include testing for hydrogen iodide removal. Tests will be conducted according to established American Society for Testing and Materials (ASTM) procedures using best estimate concentrations of hydrogen iodide for the hypothesized N Reactor accident. The filter system will be tested at concentrations which will meet or exceed the best estimate of the hydrogen iodide concentration. Filter heat loadings will be reviewed to ensure that captured iodines are not released. Dose calculations to workers and the public will be reviewed to estimate the impacts of dose commitments produced if an accident occurs.

3.1.6 Avoid Contamination Via Cooling System Interconnections

Certain penetrations of the reactor containment structure at the Three Mile Island plant proved to be inadequate to maintain containment because of leakage. This inadequacy was responsible for the major fraction of the TMI accident's environmental releases. Criteria for proper isolation of cooling systems components that penetrate N Reactor's confinement will be re-evaluated against the Three Mile Island experience and the current Nuclear Regulatory Commission General Design criteria. Isolation will be provided for any lines that may not presently meet the criteria.

3.2 Pressure Tube and Graphite Analysis

N Reactor has a formal evaluation program which monitors and analyzes the pressure tubes and the graphite. Based on the evaluation program results, the characterization and projection of future trends for these components have been routinely and rigorously accomplished and documented. Differences from the expected conditions were investigated. The results of on-going studies on both pressure tubes and graphite provide continuing assurance that operations are conducted consistent with the specifications of the components. The graphite has recently had additional intensive study, since its changing condition could potentially limit the operational life of N Reactor.

The following sections describe the pressure tube and graphite evaluation program, which now incorporate some accelerated evaluations.

3.2.1 Pressure Tube Analysis

The program to evaluate the integrity of the pressure tubes for the purpose of determining duration of useful life consists of the following: 1) removal and examination of selected tubes, 2) in situ surveillance, 3) accelerated irradiation testing, 4) hydrogen effects testing, and 5) analysis. Through 1986, nine pressure tubes had been removed from N Reactor and characterized for metallurgical properties important to safety and continued serviceability. These characterizations included visual inspection, hydrogen content measurement, and mechanical property testing including some burst tests. Using the data obtained, projections were made of the safe life expectancy of the tubes. In addition, several studies were conducted on tube seismic adequacy.

The N Reactor SEP has expanded the pressure tube data collection and analysis effort to provide an enhanced basis for predicting future pressure tube integrity. During the January-to-July 1987 standdown, four pressure tubes are being removed for examination, and 60 to 100 tubes will undergo extensive in situ nondestructive examinations (NDE). The NDE results, along with the data obtained from the four tubes removed, will be used to improve the accuracy of predicting pressure tube service life.

Other analyses and testing are also planned. These include additional evaluation of the potential for pressure tube failure, the impact that a failed graphite cooling system tube could have on the pressure tubes, and an accelerated irradiation test program to provide more extensive pressure tube material property data. In addition, elevated hydrogen concentrations will be artificially induced into samples of pressure tube materials to determine the material properties under such conditions.

Following 1987, two pressure tubes will be removed each year for at least the same tests as will be conducted with the tubes removed in 1987, and in situ NDE tests and measurements will be made on other pressure tubes.

3.2.2 Graphite Analysis

The program to manage the graphite growth consists of the following: 1) surveillance, 2) modeling consequence analysis, and 3) flux flattening (a method to control graphite growth). Surveillance has been conducted since the initial startup of N Reactor in 1964. It includes surveillance through horizontal reactor control rod channels, vertical ball safety channels, untubed channels, and special channels. Graphite specimens have been periodically removed and evaluated to assess oxidation. Accelerated graphite irradiation tests were performed in the Oak Ridge High Flux Isotope Reactor (HFIR) facility in the late 1970s to establish graphite contraction and expansion data. Additional graphite samples have been irradiated in the HFIR, and will be analyzed as part of this task. These efforts have all contributed to the graphite distortion modeling under reactor in-core irradiation conditions.

With the advent of the SEP, increased emphasis has been placed on graphite evaluation. In addition, neutron flux flattening will be used to significantly slow projected distortion. In-core neutron flux monitoring, in combination with revised fuel load patterns, will accomplish this. Tooling is being developed to provide profile measurements on control rod channels, graphite cooling system tubes, and ball channels. In-core monitoring equipment is being added to provide detailed graphite motion data. Testing of the top thermal shield components is being performed to more precisely predict the sequence of events as graphite growth occurs. The program will supplement the use of existing equipment to provide visual and physical graphite measurements.

Data obtained from the additional studies will be used to confirm and improve the graphite distortion model. The technical bases used for all such analyses will be documented so that future life projections can be refined as more comprehensive data become available.

3.3 Equipment Qualification

An Equipment Qualification Program (EQP) similar to that required for commercial reactor plants has been initiated for N Reactor. The EQP will augment existing information available on those safety-related system components that are required to operate in order to minimize the consequences of a reactor accident. The EQP backs up the design bases by assessing the operability of components under accident conditions. Currently, the N Reactor subscribes to the equipment qualification database published by the Electric Power Research Institute (EPRI). This information will provide input to the total EQP, along with the standards and codes used by the nuclear industry. The basic elements in establishing this enhancement are covered in the sections below.

3.3.1 Equipment Qualification Program Plan

An EQP plan will be developed to identify a program scope which utilizes the relevant commercial nuclear reactor codes/standards as N Reactor requirements. The N Reactor component and design records, including the safety analysis, will be used as source information for development of the EQP plan. The plan will contain lists of the equipment in the safety related systems, along with the required environmental and seismic qualification conditions. The EQP plan will be completed by June 30, 1987.

3.3.2 Equipment Testing and Analysis

Procedures for analyses, comparisons, and tests will be developed. Qualification of the identified components will be conducted and files on the results established and maintained. This work will begin in July 1987 and be completed by September 1988.

3.3.3 Maintenance Considerations

The final step in the EQP is to compare the qualified equipment against the current maintenance procedures and practices, including updates of the spare-parts inventories. This will provide assurance that all components that have been qualified will remain so. This will be completed by August of 1989 and as new components are procured and installed during maintenance upgrades.

3.4 Probabilistic Risk Assessment (PRA)

Probabilistic risk assessments have been used on a number of commercial reactors to provide an additional perspective of reactor safety and to provide additional input into the planning process for improving safety margins. A review of methods and technology for a PRA of N Reactor was initiated in 1983.

The enhanced PRA program covers assessments of plant risks that require estimates of both the probabilities and consequences of postulated N Reactor accidents. The three-level program contains the following work packages:

- o Level 1: Analysis of plant design and operation focused on the frequency of accident sequences that could lead to postulated core-damage or loss of plant availability.

- o Level 2: Analysis of the physical processes of the postulated core-damage accidents and the response of the confinement system. Predictions of the time and mode of radionuclide release as well as inventories of radionuclides released to the environment will be determined for the dominant accident sequences.

- Level 3: Analysis of the public health and economic consequences of postulated N Reactor accidents.

- External Events: Analyses of the effects of earthquakes, seismic events, floods, fires, etc. on N Reactor.

A Level 1 PRA was initiated for N Reactor in October 1985. The Level 1 program will be expedited and expanded to Level 3, including analyses of external events.

For the PRA, a number of reactor analysis computer codes currently used in the evaluation of commercial light water reactor safety are being modified for application to N Reactor. As part of this code modification, physical models of N Reactor material behavior require development. Examples of these include fission products release from metallic fuel.and molten uranium interaction with zircaloy in a steam environment.

Once the initial PRA support tasks have been completed, the analysis program will be maintained for continued use at N Reactor.

The Level I PRA focuses on a determination of the frequency of accident sequences that could lead to core damage or loss of plant availability. It will be expanded in scope and accelerated to effect completion in 1987.

The Level 2 and 3 PRA work is extensive and is being conducted by the Sandia National Laboratory. This work will be completed in 1988, with a draft by September 1988.

Figure 3.4.1 provides a simplified flow diagram of the steps involved in the performance of a Level 3 PRA.

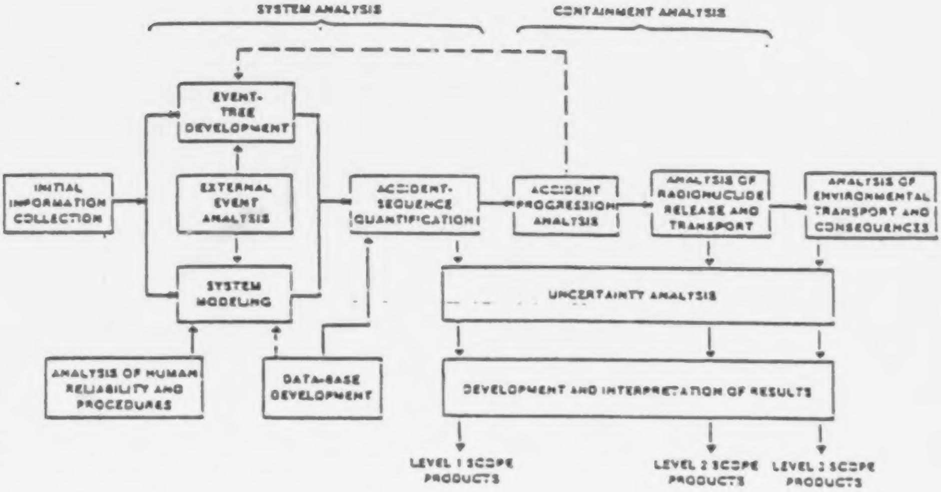
SYSTEM ANALYSIS
CONTAINMENT ANALYSIS
EVENT-TREE DEVELOPMENT
INITIAL INFORMATION COLLECTION
EXTERNAL EVENT ANALYSIS
ACCIDENT-SEQUENCE QUANTIFICATION
ACCIDENT PROGRESSION ANALYSIS
ANALYSIS OF RADIONUCLIDE RELEASE AND TRANSPORT
ANALYSIS OF ENVIRONMENTAL TRANSPORT AND CONSEQUENCES
SYSTEM MODELING
UNCERTAINTY ANALYSIS
ANALYSIS OF HUMAN RELIABILITY AND PROCEDURES
DATA-BASE DEVELOPMENT
DEVELOPMENT AND INTERPRETATION OF RESULTS
LEVEL 1 SCOPE PRODUCTS
LEVEL 2 SCOPE PRODUCTS
LEVEL 3 SCOPE PRODUCTS

Figure 3.4.1 Work Task Progression Overview for Level 3 PRA

3.5 Analysis of the Hypothetical Accident

The hypothetical accident described in the Safety Analysis Report is being reviewed and will be reanalyzed using state-of-the-art techniques with mechanistic models in current computer codes. The mechanistic treatment will include hydrogen formation by oxidation of exposed zircaloy and metallic uranium as well as fission-product-release and transport mechanisms. The treatment also will attempt to quantify fission product holdup times at each region of the N Reactor system prior to release from confinement. Hydrogen concentrations will be deter mined for each area of the confinement system as a function of time. The analyses are consistent with NRC guidance documented in NUREG-0956, "Reassessment of the Technical Bases for Estimating Source Terms". A descriptive analysis was previously completed and new best-estimate analyses will be compared with the previous work.

3.6 Hydrogen Evolution Analysis

A sensitivity study is being performed to evaluate the confinement capability to accommodate various hydrogen source rates and locations. Parallel studies are also evaluating mechanisms for hydrogen generation and the associated rates. On the basis of these studies, hydrogen monitoring and mitigation systems are being designed for installation on an expedited basis (see Section 2.5). Interaction between the ongoing PRA/severe accident modeling effort and the design/installation effort will ensure that the hydrogen monitoring and mitigation systems will provide conservative accommodation of appropriate events and considerable safety margin beyond the analyzed accidents.

3.7 Evaluation of Forms and Quantities of Iodine

The forms and quantity of iodine released from fuel under hypothesized accident conditions are important because these factors determine the amount of iodine that could eventually reach the environment.

The quantity of iodine vapor released depends on fuel temperatures, amount of fuel that experiences cladding failure, fuel configuration after cladding failure, the amount that plates out on piping and equipment surfaces and building walls, the quantity that is removed by building sprays, and the amount that is removed by filters.

The form of iodine (elemental and/or various compounds including organics) determines the effectiveness of plate-out, rain-out, and filtration.

A study will review past and current data to reevaluate the distribution and chemical forms of iodine that would be expected in the confinement volume following the postulated accident scenario. In addition, this study will provide a review of treatment methods for reducing the amount of iodine before it leaves the confinement envelope. The results of this study will be used to determine whether enhancements would be useful in increasing safety margins.

3.8 ECCS Seismic/Wind Studies

The post Chernobyl reviews of the N Reactor identified specific components and facilities related to the Emergency Core Cooling System for which there was concern regarding their ability to withstand design basis seismic and wind loadings. Analysis of their seismic and/or wind capabilities as appropriate were initiated to address these concerns. Components under evaluation include concrete block walls, emergency power batteries and related facilities, emergency diesel powered pump fuel oil supply systems, water storage facilities, portable emergency lights, reactor control room electrical panels, the fog spray system accumulator tank, high pressure air receiver tanks, and potable water tanks. These studies are scheduled to be complete by July 1987.

In the event that these studies identify areas where enhancements are appropriate, resolution activities will be identified. Completion schedules for modifications, if required, will be determined following evaluation of the impact on plant safety.

4.0 MANAGEMENT SYSTEMS AND TRAINING IMPROVEMENTS

The N Reactor SEP has initiated actions to improve management systems and training as they relate to off-normal or emergency conditions. This portion of the program has been underway for some time and will be completed by July 1, 1987.

4.1 Management Systems

The Management Systems improvements portion is being administered under three categories: Operating Procedures, Work Control Procedures, and Storage of Chemicals. Within these categories, existing N-Plant procedures and practices were evaluated against commercial nuclear plant regulatory guides and standards. The criteria or bases used in these comparisons included those developed in response to the TMI incident as formalized through Institute for Nuclear Power Operations (INPO) prorams and documents.

Management systems improvements are addressed as pre-emergency or post-emergency. From the pre-emergency perspective, existing management systems were evaluated to determine what program/procedural enhancements should be made to reduce and/or eliminate potential precursors to unusual events or emergencies. Improvements in this category deal with topics such as battery maintenance, control and storage of flammables and chemicals, Reduction of Radioactive Waste and Personnel Exposure, establishment of an Operating Experience Review program, and an expanded annual facility safety review.

Post-emergency improvements focus on the evaluation of those emergency procedures that would be used at the time of (or immediately following) plant upset, unusual event, alert, site, or general emergencies. Specific appraisal team recommendations in this category included emergency operating procedures (EOP), emergency response planning documentation, and personnel evacuation and accountability.

Implementation of these enhancements generally has entailed the augmentation or clarification of existing procedures. These procedural improvements focused on specific, clear delineations of responsibilities and lines of authority with the objective of ensuring pre-planning and documented control of the tasks covered by the procedure. The end result is assurance that off-normal evolutions will be conducted with a maximum of safety. Procedures were either developed or modified based on accepted industry standards with emphasis on applicable codes, standards, and unique N-Plant features.

In order to ensure that procedural enhancements were both comprehensive and technically appropriate, they were subjected to independent reviews by third-party technical experts.

4.2 Training

Training improvements will emphasize procedures developed or modified as part of the SEP. In addition, hands-on training/certification will be provided on new equipment as it is installed and accepted for beneficial use. The following nine items are planned for completion by July 1, 1987.

4.2.1 Remote Reactor Shutdown (See Section 2.6)

As is currently done following any plant modification or enhancement, training will be instituted for certified operators, supervisors, and managers to safely operate and monitor the remote reactor shutdown equipment. The training will focus on the newly developed procedures and on understanding the equipment applications.

4.2.2 Emergency Operating Procedures (See Section 4.1)

Retraining on these procedures will be instituted for certified staff as they are revised. As the PRAs are developed, revisions to other EOPs are possible. Training will also be conducted on these changes.

4.2.3 Certified Control Room Supervisors and Managers

Current reactor core event mitigation training is being expanded to include non-credible accident characteristics in terms of thermal hydraulics, core kinetics, and core chemical reactions. This training is specifically designed to improve skills in analyzing, diagnosing, and mitigating low-probability severe events. Useful information on PRA studies will also be included, as it becomes available, in the recertification training program.

4.2.4 Simulator Training

Exercise guides will be provided as simulator enhancements are developed for the various normal, off normal, and emergency events using new "equipment" and procedures. These guides will establish the initial simulator conditions, the learning objectives of the training, and performance standards for successful training completion.

4.2.5 Full Apparel Training

Control room personnel will be trained to perform normal and off-normal operations on the simulator while wearing self-contained breathing air apparatus and/or other protective apparel. Exercise guides, similar to those in 4.2.4 above, will be developed and used.

4.2.6 Graphite Oxidation Considerations

Training on material that provides understanding of the processes of graphite oxidation, the conditions that can affect oxidation, and the N Reactor design conditions that preclude graphite oxidation will be provided.

4.2.7 Shift Manager Emergency Duties

In accordance with normal practice, the shift managers will receive special training on all modified procedures and on equipment that is new or modified. This training will focus on their responsibilities and duties as Area Emergency Directors.

4.2.8 Refueling Supervision Qualification

Supervisors in charge of refueling operations will be given a formal qualification training covering all charge/discharge fuel handling operations. Certification of all such staff members is required.

4.2.9 INPO Certification

The N Reactor technical training programs, developed to the same standards as those used at commercial facilities, will be submitted to Institute for Nuclear Power Operations (INPO) for certification as meeting "INPO Accreditation Criteria." Training programs that will be submitted for accreditation include those for:

- Certified Control Room Supervisor
- Certified Reactor Operator
- Radiation Protection Technician
- Chemistry Technician
- Non-Certified Operator
- Maintenance Crafts
- Technical Support Staff

5.0 CONCLUSION

DOE is committed to not only achieving an acceptable level of safety, but also to pursuing safety excellence at N Reactor. To this end, DOE has initiated an aggressive, responsive Safety Enhancement Program to further increase the margin of safety at N Reactor. The highly unusual Chernobyl accident provided the impetus for DOE to accelerate its safety reviews and to accelerate implemention of enhancements to the safety of N Reactor; however, the Safety Enhancement Program is part of a continuing process fostered by DOE's commitment to protect the health and safety of the public.

The Safety Enhancement Program will provide for plant modifications at N Reactor resulting in a lower probability of severe accidents. Technical studies and evaluations will be performed to provide added assurance that an adequate margin of safety is being maintained. This program will also provide for improved management systems and training for the operators of N Reactor.

APPENDIX

DEFINITIONS

The following acronyms are defined in alphabetical order.

ACRS	Advisory Committee on Reactor Safeguards
ASEH	Assistant Secretary for Environment, Safety and Health
ASTM	American Society for Testing and Materials
DOE	Department of Energy
ECC	Emergency Control Center
ECCS	Emergency Core Cooling System
EOP	Emergency Operating Procedures
EPRI	Electric Power Research Institute
EQP	Equipment Qualification Program
GAO	Government Accounting Office
HFIR	High Flux Isotope Reactor
IEEE	Institute of Electrical and Electronic Engineers
INPO	Institute for Nuclear Power Operations
LERF	Liquid Effluent Retention Facility
MWt	Megawatts thermal
NAE	National Academy of Engineering
NAS	National Academy of Sciences
NDE	Non-Destructive Examinations
NRC	Nuclear Regulatory Commission
NUSAR	N Reactor Updated Safety Analysis Report
OSC	Operational Support Center
PRA	Probabilistic Risk Assessment
psig	pounds per square inch gauge
SEP	Safety Enhancement Program
Supply System	Washington Public Power Supply System
TMI	Three Mile Island
TSC	Technical Support Center

Nuclear Weapons Databook

Volume II
U.S. Nuclear Warhead Production

by

Thomas B. Cochran, William M. Arkin, Robert S. Norris,
and Milton M. Hoenig

A book by the
Natural Resources Defense Council, Inc.

BALLINGER PUBLISHING COMPANY
Cambridge, Massachusetts
A Subsidiary of Harper & Row, Publishers, Inc.

Chapter Three

Nuclear Materials: Production, Inventories, Initiatives

Production of Nuclear Materials

Energy equivalent to thousands or even millions of tons of TNT is released in a nuclear weapon explosion by the fission and fusion of atomic nuclei.[1] Six nuclear materials are used in nuclear weapons. They are the fissionable materials, uranium-235, plutonium-239, and uranium-238, and the thermonuclear materials, tritium, deuterium, and lithium-6.[2] Except for U-238, which is abundant in nature, all of these materials must be produced or concentrated in special facilities. This chapter discusses the production of these nuclear materials, provides estimates of inventories and production rates, and surveys the initiatives planned to increase materials production.

The different materials require different production facilities. Plutonium and tritium are manufactured in production reactors. Uranium-235 is separated out of natural uranium (which is 99.3 percent U-238) in enrichment plants. Deuterium, in the form of heavy water, is produced in heavy water production plants. Lithium-6 is separated from compounds of naturally occurring lithium (which is 92.4 percent lithium-7) in special enrichment facilities. All these materials except for tritium (because of its short half-life) can be stockpiled for extended periods.

A production reactor depends on several facilities to support its operations. Other plants are required to manufacture the fuel; to separate the plutonium, tritium, and uranium from the spent fuel; and to dispose of the waste products. All these facilities, together with their transportation links, constitute the reactor "fuel cycle."

Often, the same facilities support production reactors as well as supplying materials for warheads. The uranium enrichment complex, for example, is an integral part of the fuel cycle for some production reactors and also produces U-235 for weapons. Similarly, heavy water, the source of deuterium for weapons, is also used as reactor moderator and coolant in heavy water production reactors. Complicating these matters, the fuel used in some U.S. production reactors is obtained, in part, from uranium recovered from the spent fuel of naval, research, and test reactors.

Of the four kinds of production facilities, only the production reactors add new materials (plutonium and tritium) to existing U.S. inventories at this time. U.S. production of highly enriched uranium (HEU) for weapons was terminated in 1964. Highly enriched uranium, however, is currently produced in U.S. enrichment plants to fuel naval propulsion, research and test reactors, and commercial reactors. The United States plans to resume HEU production for weapon use near the end of the decade. U.S. heavy water and lithium enrichment facilities are not now operating. Supplies of these materials come from weapons that have been retired and dismantled and from other existing stockpiles.

In the United States, in fact, most nuclear materials for new weapons comes from retired weapons. These materials must first be recovered, purified, and processed before re-use.

Later in this chapter there is a discussion of several reasons for a number of initiatives that have led to the current plans to expand materials production.[3]

Plutonium and Tritium Production

The U.S. Department of Energy (DOE) currently produces plutonium and tritium for the weapon program in five operating production reactors.[4] Four of these—the P, K, L, and C-Reactors—are at the Savannah River Plant (SRP) in Aiken, South Carolina. The fifth, the N-Reactor, is on the Hanford Reservation, near Richland, Washington. The L-Reactor at Savannah River, placed on standby in 1968, was restarted on 31 October 1985, following a two year delay to correct environmental problems.

Since 1944, the United States has operated a total of fourteen plutonium production reactors: the eight original graphite-moderated water-cooled reactors and the dual-purpose N-reactor at Hanford and five heavy water-moderated reactors at Savannah River. The number of reactors producing plutonium or tritium for weapons grew from three during World War II to fourteen by 1964, then dropped to three by 1971.

---

[1] Thomas B. Cochran, William M. Arkin, and Milton M. Hoenig, *Nuclear Weapons Databook, Volume I, U.S. Nuclear Forces and Capabilities* (Cambridge, Massachusetts: Ballinger Publishing Company, 1984), Chapter Two: Nuclear Weapons Primer, for an explanation. Hereafter cited as *Nuclear Weapons Databook, Volume I*.

[2] Thorium-232 and uranium-233 are weapon-usable, fissionable materials but without significant application in weapons programs. Plutonium isotopes Pu-240, 241, and 242 are fissionable and present in small amounts with Pu-239 in weapon-usable plutonium. Lithium-6 may be diluted with the more abundant isotope lithium-7, at the cost of efficiency.

[3] Requirements for nuclear weapon materials are set forth in the annual *Nuclear Weapons Stockpile Memorandum* (NWSM). Production workloads for specific facilities are detailed in the annual DOE Materials Management Plan. Chapter Four discusses in more detail these and other nuclear weapon planning documents.

[4] Other isotopes (namely, Pu-238, Am-241, U-233, Cf-252) used for defense, research, medical, and commercial applications have also been produced in these reactors.

[5] For a fuller discussion see John R. Lamarsh, *Introduction to Nuclear Engineering* (Reading, Massachusetts: Addison-Wesley Publishing Company, 1975), p. 75.

Measuring Production

The production of plutonium and tritium in reactors occurs by means of neutron capture in respective target materials, U-238 and lithium-6. Consequently, the production rates of plutonium and tritium depend on two factors: the rate at which neutrons are produced, by fissions of the fuel materials, and the probability of neutron capture in the targets. Both depend on the design of the reactor. Fissioning each atom of U-235 (or Pu-239) not only results in the release of two to three neutrons but is also accompanied by the release of about 200 MeV of energy, mainly in the form of kinetic energy of the fission products. Most of this energy is ultimately converted into heat.[5] Thus, for a given reactor type, the reactor power, the rate at which uranium fuel is consumed, and the rate at which plutonium (or tritium) is produced are all closely coupled.

As a practical rule of thumb, in a reactor designed for the production of weapon-grade plutonium (or tritium), one gram of plutonium (or 1/72 gram of tritium) is produced for each gram of U-235 fissioned, which is accompanied by the release of one megawatt-day of thermal energy (1 Mwd) (see Chapter Five, Production Reactors). The actual design-dependent production rates are within about 20 percent of these values. The maximum rates of plutonium and tritium production thus can be readily estimated from knowledge of the reactor type and its rated power, measured in megawatts thermal (Mw_t). The actual amounts produced depend on operating power levels and the period of time the reactor is on line.[6]

A Brief History of Reactor Operations

Nuclear reactors for the production of plutonium date back to the Manhattan Project during World War II. Enrico Fermi produced the first self-sustaining chain reaction in the Chicago Pile (CP-I) on 2 December 1942. This original reactor (or pile) was fueled with lumps of natural uranium oxide embedded in a lattice of graphite moderator.

The design had no cooling and required dismantling to recover the plutonium. It required modification to make it suitable for a production reactor. The deficiencies were corrected in the 1 Mw Clinton Pile (later designated X-10) near Clinton, Tennessee (now Oak Ridge). On 4 November 1943, the Clinton Pile began operations as a pilot production plant for urgently needed plutonium. The air-cooled Clinton Pile consisted of a block of graphite with horizontal channels through which aluminum clad cylinders of uranium could be pushed from front to back for discharge.

In September 1943, before the Clinton Pile's completion, construction began at the Hanford Reservation on the B-Reactor, the first of three full-scale, graphite-moderated production reactors. The B-Reactor began operation a year later in September 1944. It was graphite-moderated and water-cooled and was fueled with natural uranium—the first of eight such reactors built at Hanford between 1943 and 1952.[7] Two others (D, F) also began operation during World War II. By the end of the war, serious deterioration of the B, D, and F-Reactors resulted from intensive operation. They all required major overhaul and reconditioning at Hanford. The B-Reactor was shut down in March 1946 to assure some production capability should the other two reactors fail. Repairs to the reactor, started at the end of 1947, were scheduled during periods of normal shutdown so as to not interrupt plutonium production. This work was finished by mid-1948, when the B-Reactor was also restarted. Late in 1948 the production rates of the B, D, and F-Reactors surpassed any achieved in wartime.[8]

The eight original Hanford reactors operated between 1944 and 1971 for a total of 139 reactor-years. Table 3.1 shows their operating histories. All eight reactors have now been retired and are being dismantled. They are not considered to have any restart capability.[9]

The first four reactors (B, D, DR, F) were originally powered at 250 Mw_t. These and the next two reactors (H, C) were extensively modernized and uprated in the 1950s and early 1960s. They eventually operated with power limits of 2090 to 2310 Mw_t.[10] The last two of the original graphite reactors (KE, KW) began operating in 1955, each with a design power level of 1850 Mw_t. Both were upgraded to 4400 Mw_t before being shut down in 1970 and 1971, respectively. The eight reactors had an average lifetime power of 1120 Mw_t per reactor. Additional characteristics of the Hanford graphite reactors are described in Volume III, Hanford Reservation.

The 4000 Mw_t N-Reactor—the ninth production reactor to be constructed on the Hanford Reservation—has been in operation since 31 December 1963. In the late 1960s and 1970s, it continued to operate during a slump in demand for materials, because it was a source of electrical power.[11] During this period it mainly produced fuel-grade plutonium for the research program. It was not used to produce significant quantities of weapon-grade plutonium until 1982.

The life of the N-Reactor will extend until about 1998, when irreversible damage to the blocks of graphite moderator will make operation increasingly difficult. DOE has begun studies on extending N-Reactor's useful lifetime.[12]

---

[6] The period of time on line depends on such factors as length of a production cycle, the refueling interval, and the downtime for maintenance. U.S. production reactors are typically on line 50 percent (N-Reactor) to 80 percent (SRP reactors) of the time. In commercial reactors, performance is expressed as a "capacity factor," defined as the electrical output as a percentage of the plant design capability. In recent years, the average capacity factor of U.S. power plants has been about 65 percent.

[7] While water was chosen, prior to 1943 helium gas had been thought to be the only acceptable coolant.

[8] AEC, Report to Congress, January 1949, p. 26.

[9] HAC, FY 1980 EWDA, Part 7, p. 2638; HASC, FY 1980 DOE, p. 258.

[10] Early consideration had also been given to the use of fast reactors to breed plutonium. The experimental breeder reactor (EBR-I) went into operation in Idaho in 1951, demonstrating breeding in 1953. However, the use of breeder technology for the U.S. weapon program was not pursued, the program favoring more certain thermal reactors.

[11] DOE, Report of the New Production Reactor Concept and Site Selection Advisory Panel, Q-DO-82-97, 15 November 1982, p. 25.

[12] HAC, FY 1985 EWDA, Part 4, p. 426.

3

Savannah River Production

Operation of production reactors, moderated and cooled by heavy water, at Savannah River commenced in December 1953 with the R-Reactor. It was followed by the P, L, and K-Reactors in 1954 and the C-Reactor in 1955 (see Table 3.1). The R- and L-Reactors were placed on standby and shut down in June 1964 (R) and February 1968 (L), while the P, K, and C-Reactors have continued operation. Through 1985, the Savannah River reactors compiled a total of 114.9 reactor-years of operation.

Planning for construction of the Savannah River heavy water reactors began in earnest following President Truman's 31 January 1950 decision to authorize the development of thermonuclear weapons. Truman approved the AEC construction program for the Savannah River Plant on 8 June 1950. Although the feasibility of thermonuclear weapons was still problematical at that time, the motivation was to ensure tritium production, still thought to be necessary in large quantities for use in high yield thermonuclear weapons.[13]

Meanwhile, tritium had to be supplied for the thermonuclear research program without seriously curtailing the plutonium production at Hanford for the existing fission weapons program. Personnel at Hanford successfully attacked the technical problems of making tritium. Using 10 percent of the capacity of one of the production reactors, they provided Los Alamos with enough of the element for research.[14]

The anticipated heavy demand for tritium subsided as weapon design moved to favor using lithium-6 deuteride in the fusion stage of thermonuclear weapons.[15] But the flexibility of the heavy water reactors for the production of either tritium, plutonium, or uranium-233 had been one of their selling points. The Savannah River project was initiated in an environment of increasing demand for all nuclear materials. From the start its cost was said to be almost entirely justified by new plutonium production capacity alone, should thermonuclear weapons not prove feasible. This view held sway especially since the existence of sizeable domestic deposits of uranium ore was still unproven, but also because of plutonium's utility in small diameter tactical nuclear weapons. The Savannah River reactors were also justified as insurance against the failure of Hanford and as a replacement for the older Hanford reactors.[16]

Savannah River Production

The production history for the Savannah River reactors from FY 1955 to FY 1983 is shown in Figure 3.1. The annual plutonium and tritium production, including projections to FY 1999, are given in Table 3.2. With three reactors on line, SRP was producing (FY 1985) about 1.0 MT of supergrade plutonium and 11 kg of tritium annually. With the restart of the L-Reactor the rate of plutonium production increased to about 1.6 MT (see Table 3.2).

Selected documents and reports give additional information on the operation of the P, K, and C-Reactors since the early 1970s. The highest power achieved in any reactor prior to 1977 was 2915 Mw_t,[17] but the typical nominal reactor power for plutonium production, up to the mid-1970s, was about 2150 Mw_t (2000 to 2200 Mw_t) and 2400 Mw_t for a reactor producing tritium.[18] During FY 1977-79 the three reactors were at times operated at a power of about 1850 Mw_t each, and none of the reactors were dedicated to tritium production alone. Production cycles for weapon-grade plutonium lasted an average of 60 days. A minimum three-day shutdown followed, to allow fuel-changing machines to remove and replace irradiated target assemblies.[19]

A contrast between operations in the middle and late 1970s is provided by the following report of activities. The Savannah River reactors completed ten production cycles during a six-month period in FY 1976.[20] During FY 1977-79, at a reduced level of production, forty-two cycles were completed while one of the three reactors was shut down for a period of six months. Eight cycles were finished during an eight-month period in 1980.[21] These activities are reflected in the 20 percent drop in the rate of production in FY 1977-80 compared to the rate in FY 1976. (See Table 3.2.)

There was only one dedicated tritium campaign, for an eight-month period, in the decade prior to 1981.[22] A tritium production run in 1972 is reported[23] and another was scheduled for late 1981.[24] Subsequently, one of the production reactors (C-Reactor) has been dedicated solely to the production of tritium.[25] To meet the tritium requirement projected in the 1984 Nuclear Weapons Stockpile Memorandum, an average of 1.2 reactors will have to be dedicated to tritium production through FY 2000.[26]

---

[13] Lee Bowen, The United States Air Force Historical Division, *A History of the Air Force Atomic Energy Program 1943-1953, Volume IV, The Development of Weapons* (Washington, D.C.: U.S. Air Force Historical Division History, 1955, declassified with deletions June 1981), pp. 31-33.

[14] Ibid.

[15] By 1953 there was a large-scale program for the production of lithium-6 at the Oak Ridge Reservation in preparation for the 1954 thermonuclear weapons tests. The first two shots of the Castle series, Bravo and *Romeo*, confirmed the practicality of stockpiling lithium deuteride ("dry") bombs, and as a result of the Castle tests the requirements for tritium production was significantly reduced.

[16] Bowen, *Development of Weapons*, pp. 33-38.

[17] J.A. Smith, et al., "Safety Analysis of Savannah River Production Reactor Operation," E.I. duPont de Nemours & Co., Savannah River Laboratory, DPASTA-100-1 Rev. 12/76, issued September 1972, revised December 1976, p. VI-43.

[18] Ibid., pp. V-28, V-28, VI-43. Documented operating powers are, for 18-19 August 1966 (observed), 2238 Mw_t (C-Reactor), 1494 Mw_t (K), and 2082 Mw_t (L); for 25-28 August 1950 (calculated), 2250 Mw_t (C), 2100 Mw_t (K), 2100 Mw_t (L); J.S. Neill and D.F. Babcock, "The Dissipation of Reactor Heat at the Savannah River Plant," DP-1274, Savannah River Laboratory, Aiken, SC, October 1971, p. 62.

[19] Joseph Albright, Cox News Service, 14 May 1981; R. Cochran, Acting Director of Nuclear Production, DOE, Briefing Session before the Subcommittee on Nuclear Regulation of the Senate Committee on Environment and Public Works, 8 December 1981, p. 7 (see Savannah River Plant, Volume III). Smith indicates an exposure of 440,000 Mwd for Savannah River Mark 16 HEU driver assemblies over three plutonium production cycles; this averages to fifty-five days at 2150 Mw_t or sixty-three days at 1850 Mw_t for each cycle: Smith, "Safety Analysis," p. V-31.

[20] Albright, Cox News Service.

[21] Ibid.

[22] Ibid.

[23] Smith, "Safety Analysis," p. V-25. This is consitent with SRP atmospheric release data for tritium (see Table C.1 in Appendix C.)

[24] Albright, Cox News Service.

[25] HAC, FY 1985 EWDA, Part 4, p. 423.

[26] J.S. Allender and I.M. Macafee, *Economic Analysis of the Fuel Production Facility*, DPST-84-420, Savannah River Laboratory, Technical Division, 6 April 1984, pp. 5, 24. See also, HASC Rept. 98-124, Part 1, 13 May 1983, p. 18.

Table 3.1

A. Operating Histories of U.S. Production Reactors
Original Eight Hanford Graphite Reactors

Reactor	Construction Began	Operation Startup	Operation Shutdown	Years of Operation
B	09/1943	09/1944	03/19/1946[a]	
		07/02/1948[a]	02/12/1968	21.1
D	11/1943	12/1944	06/26/1967	22.5
F	12/1943	02/1945	06/25/1965	20.3
H	03/1948	10/1949	04/1965	15.5
DR	12/1947	10/1950	12/30/1964	14.2
C	06/1951	11/1952	04/25/1969	14.4
KW[b]	11/1952	01/1955	02/01/1970	15.1
KE[c]	01/1953	04/1955	01/28/1971	15.7
			TOTAL	138.8

B. Hanford Graphite Reactor Power Level Limits, Megawatts

	Original Design Level	Effective Date of Limits[d]						
		01/31/58	01/16/59	01/09/61	12/02/63	02/18/64	03/04/64	09/01/68
B	250	1440	1900	2090	1940	2090	e	f
D	250	1440	1900	2090	2005	2090	e	f
DR	250	1440	1900	2090	1925	2090	e	f
F	250	1440	1900	2090	1935	2090	e	f
H	400	1440	1900	2090	1955	2090	e	f
C	650	1740	2100	2310	2310	2310	e	e
KE	1850	3140	4000	4400	4400	4400	4400	g
KW	1850	3140	4000	4400	4400	4400	4400	g
TOTAL		15,220	19,600	21,560	20,870	21,560		

C. Hanford N-Reactor

Reactor	Construction Began	Operation Startup	Operation Shutdown	Years of Operation through 1985
N	1958	12/31/1963	operating	22.0

D. Savannah River Heavy Water Reactors

Reactor	Construction Began	Operation Startup	Operation Shutdown	Years of Operation through 1985
R	6/1951	12/1953	6/15/1964[h]	10.5
P	7/1951	2/1954	operating	30.8
L	10/1951	7/1954	2/18/1968[h]	13.6
		10/31/1985[i]	operating	0.2
K	10/1951	11/1954	operating	30.1
C	2/1952	3/1955	operating	29.7
			TOTAL	114.9

---

[a] B was shut down on 19 March 1946 and restarted on 2 July 1948; letter, John L. Meinhardt, Director, Office of Nuclear Materials Production, 4 June 1985, to Thomas B. Cochran; see also Richard G. Hewlett and Francis Duncan, *Atomic Shield, A History of the United States Atomic Energy Commission*, Volume II 1947/1952 (U.S. Atomic Energy Commission, 1972), pp. 174-75, 669.

[b] K West.

[c] K East.

[d] Reactors limited to the maximum power level that had previously been achieved.

[e] Effective 4 March 1964, the power level limits of 2090 and 2310 Mw were removed and a bulk outlet water temperature limit of 95.0 Celsius was established. Maximum power levels were in the 2000 to 2100 Mw range for B-Reactor, D-Reactor, DR-Reactor, F-Reactor, and H-Reactor, and 2300 Mw range for C-Reactor.

[f] Reactors were shut down prior to 1 September 1968.

[g] Effective 1 September 1968, top-of-riser pressure and process tube power limitations were imposed at both K-Reactors. Maximum power levels were in the 4000 to 4200 Mw range. An administrative maximum level of 4000 Mw was imposed late in 1968.

[h] Placed on "standby."

[i] The L-Reactor scheduled restart in October 1983 was delayed until 31 October 1985 to correct environmental problems.

3

Reactor Operating Histories

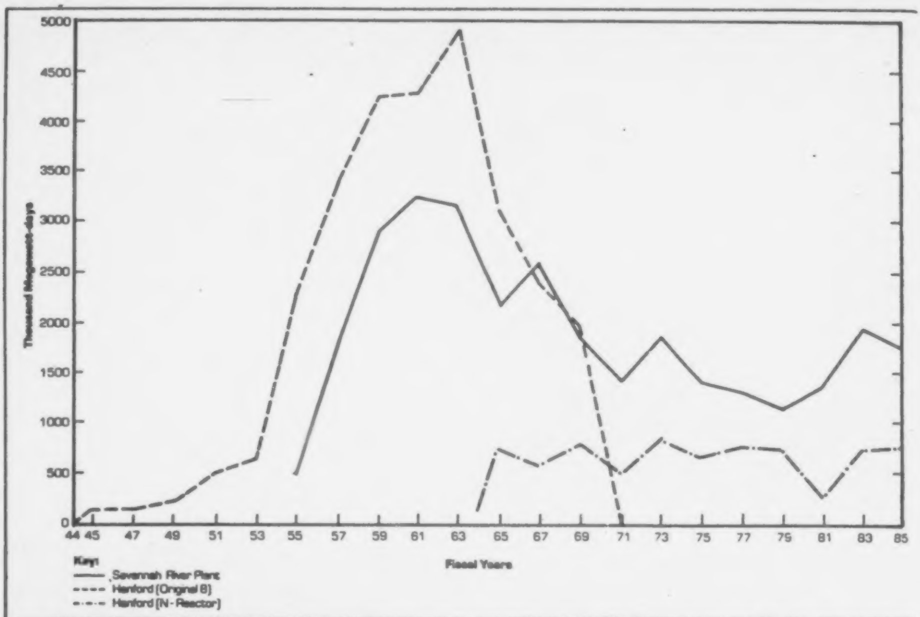

Figure 3.1 Operating histories of U.S. production reactors. Annual thermal energy output (in thousands of megawatt-days) for the U.S. production reactors. The outputs of the original eight graphite reactors, the N-reactor at Hanford, and the five heavy water reactors a the Savannah River Plant are shown separately.

Even in the reactors dedicated to plutonium production, tritium is generated in enriched lithium control rods, used to absorb excess neutrons, and in lithium targets. Annual production rates of plutonium vary because the first priority is to satisfy the tritium requirement, which varies from year to year. The remaining SRP capacity is devoted to plutonium.[27] The highly enriched uranium driver assemblies used for plutonium production (Mark 16B) have the option to contain a separately dischargeable lithium-aluminum target inside the inner fuel tube.[28] In addition, the reactor cores are now blanketed with a ring of lithium targets to shield the stainless steel reactor tank walls from neutron irradiation.[29]

The combined production of tritium from secondary sources is estimated at 0.002 g/Mwd, of which one half is assumed to be generated in control rods.[30] This was clearly the chief mode of tritium production from the mid-1970s through 1981. During this period the three operating SRP reactors would have produced between 2.4 and 2.9 kg of tritium annually, enough to maintain a steady state tritium inventory of some 46 kg against radioactive decay (see Appendix C).

The three operating Savannah River reactors (P, K C) were scheduled to run at full capacity in FY 1981 and FY 1982.[31] The goal was fully achieved in FY 1982 when the "innage" (or percentage of clock time of reactor operation) rose to 80 percent as reported by DOE. By then the restoration and upgrade program was improving the efficiency of operation. Reactor operating power for plutonium production was back up to a nominal 2150 Mw$_t$ The innage since January 1981 was reported, in Augus 1982, to be more than 80 percent.[32] During the first quar-

---

[27] Ibid.

[28] Smith, "Safety Analysis," p. V-4.

[29] D.A. Ward, et al., Extended Service Life of Savannah River Plant Reactors, DPST-80-539, Savannah River Laboratory, Aiken, S.C., October 1980, p. 8; E.D. Dukes and R.W. Benjamin, Savannah River Plant Airborne Emissions and Controls, DPST-82-1054, Savannah River Laboratory, Aiken, S.C., 1982, p. 4-4.

[30] The estimate for control rods is based on published data for the reactivity worth of the control rods during exposure. See Savannah River Production Reactors, Chapter Four.

[31] HASC, FY 1982 DOE, p. 126.

[32] Memorandum of Herman E. Roser to the Secretary of Energy, Major Accomplishments a the Savannah River Plant Since January 1981, DP-3.2, 28 July 1982.

Table 3.2

Estimated Nuclear Materials Production in Savannah River Reactors

FY	Number Reactors Operating[a]	Annual Thermal Output[b] (1000 Mwd)	Cumulative Thermal Output (1000 Mwd)	Annual Plutonium Equivalent[c] (kg)	Cumulative Plutonium Equivalent[c] (kg)	Annual Plutonium[c] (kg)	Annual Tritium[d] (kg)	Unit Costs[e] ($ per Mwd)
1955	5	500	500	485	0.5			
1956	5	1225	1725	1190	1.7			
1957	5	1825	3550	1770	3.4			
1958	5	2100	5650	2040	5.5			
1959	5	2900	8550	2815	8.3			
1960	5	3125	11,675	3030	11.3			
1961	5	3225	14,900	3130	14.5			
1962	5	3175	18,075	3080	17.5			
1963	5	3150	21,225	3055	20.6			
1964	5.4[f]	3225	24,450	3130	23.7			
1965	4	2125	26,575	2060	25.8			
1966	4	2200	28,775	2135	27.9			
1967	4	2600	31,375	2520	30.4			
1968	4.3[g]	2475	33,850	2575	33.0			
1969	3	1750	35,600	1820	34.8			
1970	3	1500	37,100	1560	36.4			
1971	3	1425	38,525	1480	37.9			
1972	2.2(W)&0.8(T)	1750	40,275	1820	39.7	1150	10.7	
1973	3(W)	1885	42,160	1960	41.6	1695	3.8	
1974	3(W)	1910	44,070	1985	43.6	1720	3.8	
1975	3(W)	1410	45,480	1465	45.1	1270	2.8	
1976[h]	3(W)	2025	47,505	2105	47.2	1820	4.0	
1977	3(W)	1310	48,815	1360	48.6	1180	2.6	
1978	3(W)	1210	50,025	1260	49.8	1090	2.4	86
1979	3(W)	1190	51,215	1240	51.1	1070	2.4	85
1980	3(W)	1450	52,665	1510	52.6	1305	2.9	74
1981	3(W,S)	1380	54,045	1435	54.0	1240	2.8	80
1982	2(W,S)&1(T)	1850	55,895	1925	55.9	1075	11.3	67
1983	2(S)&1(T)	1850	57,745	1925	57.9	1070	10.7	
1984	2(S)&1(T)	1900	59,645	1975	59.8	1100	10.7	
1985	2(S)&1(T)	1750	61,395	1820	61.7	1010	10.7	
1986	3.3(S)&0.7(T)	2310	63,705	2400	64.1	1680	9.7	
1987	3.1(S)&0.9(T)	2330	66,035	2425	66.5	1590	11.0	
1988	3(S)&1(T)	2330	68,365	2425	68.9	1545	11.6	
1989	3(S)&1(T)	2340	70,705	2435	71.3	1505	12.2	
1990	2.7(S)&1.3(T)	2360	73,065	2455	73.8	1370	14.2	
1991	2.1(S)&1.9(T)	2410	75,475	2505	76.3	1060	18.7	
1992	2.3(S)&1.7(T)	2390	77,865	2485	78.8	1150	17.4	
1993	2.6(S)&1.4(T)	2370	80,235	2465	81.3	1325	14.8	
1994	2.5(S)&1.5(T)	2370	82,605	2465	83.7	1280	15.5	
1995	2.7(S)&1.7(T)	2390	84,995	2485	86.2	1150	17.4	
1996	2.6(S)&1.4(T)	2370	87,365	2465	88.7	1325	14.8	
1997	3.2(S)&0.8(T)	2320	89,685	2415	91.1	1635	10.3	
1998	3.3(S)&0.7(T)	2310	91,995	2400	93.5	1680	9.7	
1999	3.2(S)&0.8(T)	2320	94,315	2415	95.9	1635	10.3	

---

[a] W = weapon-grade plutonium; S = supergrade plutonium; T = tritium. For FY 1986-99 the number of reactors dedicated to tritium production is given in J.S. Allender and I.M. Macafee, *Economic Analysis of the Fuel Production Facility*, DPST-84-420, pp. 5, 24 and based upon the projected tritium requirements given in the 1984 Nuclear Weapons Stockpile Memorandum.

[b] Values for FY 1955-71 from graph in HASC, FY 1985 DOE, p. 333. Values for FY 1972-82 from graph in HASC, FY 1984 DOE, p. 272. Values for FY 1983-84 from graph in HASC, FY 1986 DOE, p. 240. Data for FY 1985-99 are authors' estimates.

[c] Based on 0.97 gram (1955-67) and 1.04 gram (1968-) plutonium equivalent per megawatt-day of thermal energy output.

[d] Assumes 1 gram of tritium output is equivalent to 72 grams weapon-grade plutonium; HASC, FY 1982 DOE, p. 172. Includes 0.002 g of tritium per Mwd produced in plutonium producing reactors in control rods, blankets, and targets.

[e] Constant FY 1982 dollars; from graph in HASC, FY 1984 DOE, p. 272.

[f] R-Reactor shutdown in June 1964.

[g] L-Reactor shutdown in February 1968.

[h] A 15 month fiscal year.

[i] L-Reactor restarted 31 October 1985.

Table 3.3
Estimated Plutonium Production in the Eight Original Hanford Graphite Reactors

Calendar Year	Number Reactors Operating	Annual Th. Output[a] (1000 Mwd)	Average Reactor Power (Mw_t)	Annual Pu Prod.[b] (kg)	Cumulative Pu Prod. (MT)
1944	0.3	21	175	18	0.02
1945	1.9	120	175	103	0.12
1946	2.1	141	175	121	0.24
1947	2.0	128	175	110	0.35
1948	2.5	160	175	138	0.49
1949	3.2	213	181	183	0.67
1950	4.2	307	200	264	1.94
1951	5.0	500	273	430	1.37
1952	5.1	1000	534	860	2.23
1953	6.0	1250	570	1075	3.30
1954	6.0	1500	684	1290	4.59
1955	7.5	2250	812	1935	6.53
1956	8.0	2500	856	2150	8.68
1957	8.0	3400	1164	2924	11.60
1958	8.0	2900	993	2494	14.09
1959	8.0	4250	1455	3655	17.75
1960	8.0	4750	1626	4085	21.73
1961	8.0	4300	1472	3698	25.53
1962	8.0	4500	1541	3870	29.40
1963	8.0	4900	1678	4214	33.62
1964	8.0	4016	1371	3454	37.07
1965	5.7	3140	1496	2700	39.77
1966	5.0	3550	1945	3053	42.82
1967	4.4	2400	1474	2064	44.89
1968	3.1	2200	1928	1892	46.78
1969	2.2	1950	2331	1677	48.46
1970	1.1	750	1826	645	49.10
1971	0.04	0	0	0	49.10
TOTALS	138.8	57.170		49,167	

[a] Values for years 1951-1971 are from DOE. See Letter from John L. Meinhardt, Director, Office of Nuclear Materials Production, DOE to Thomas B. Cochran, which includes N-Reactor production. Values for 1944-1950 are based on the assumption that the reactors operated at 70 percent capacity.

[b] Assumes 0.86 grams plutonium produced per megawatt-day of thermal energy output. See ACDA, "Criticality Studies of Graphite Moderated Production Reactors," Contract No. AC9NX707, January 1980. No correction has been made here for the small quantities of non-defense plutonium, U-233, Pu-238, Co-60 and C-14 known to have been produced. These corrections are made at Table 3.13.

ter of FY 1982 the reactors operated at an 85 percent innage.[33] Reports indicated that "Savannah River reactors have operated 38% more efficiently than planned . . . during the first 9 months of FY 1982,"[34] and "FY [19]82 materials production is the highest since 1974, and is 143 percent of the program milestone."[35] Furthermore, reactor power levels "exceeded records" with the K reactor operating at higher power than ever before.[36] The result was that the "plutonium and tritium production goals have exceeded the forecasts,"[37] and "at levels substantially exceeding our fiscal year 1982 plan."[38] In FY 1983, the innage was 75 percent with operation again at higher power levels.[39]

This expanding production environment has continued for FY 1984 and FY 1985, although meanwhile the plutonium output was converted (by FY 1983) entirely to supergrade (high-purity) production, for blending.[40] Making supergrade plutonium requires halving target

---

[33] HASC, FY 1983 DOE, p. 418.

[34] Memorandum of Herman E. Roser, op. cit.

[35] DOE, Major Accomplishments at the Savannah River Plant Since January 1981, August 1982. The milestone was probably 60 to 80 percent.

[36] HASC, FY 1984 DOE, p. 273.

[37] Ibid.

[38] Ibid., p. 131.

[39] HASC, FY 1985 DOE, p. 332.

[40] "We . . . have been exceeding our production goals." In FY 1983 C, K, and P-Reactors obtained more than 1.65 million Mwd of production while operating at an on-line availability (innage) of 75 percent. "C-Reactor has already [prior March 1984] achieved its highest power level since March 1969, and has set monthly production records this past December and January . . . and we have set a new calendar year production record (1983) for three-reactor operations;" HASC, FY 1985 DOE, pp. 331-33. "Our production reactors are operating at the highest capacity ever": HASC, FY 1986 DOE, p. 37.

Table 3.4
Production History of the Hanford N-Reactor

Calendar/ Fiscal Year	Annual Production[a] (1000 Mwtd)	Thermal Capacity Factor[b]	Cumulative Production (1000 Mwd)	Annual Pu Prod.[c] (kg)	Plutonium Mode[d]	Cumulative Pu Prod. (MT)[e]	Cumulative Weapon-Grade Pu Production (6% Pu-240)	Annual Electricity Production[f] (million Kwh)	Cumulative Electricity Production (million Kwh)
Cal. 1964	234	0.16	234	201.24	W(6)	0.201	0.20	0	0
1965	660	0.45	894	567.60	W(6)	0.768	0.76	0	0
1966	750	0.51	1644	592.50	F(9)	1.361	0.76	1012	1012
1967	600	0.41	2244	474.00	F(9)	1.835	0.76	2056	3067
1968	850	0.58	3094	671.50	F(9)	2.506	0.76	3963	7030
1969	800	0.55	3894	632.00	F(9)	3.138	0.76	3924	10,954
1970	550	0.38	4444	434.50	F(9)	3.573	0.76	2702	13,656
1971	500	0.34	4944	395.00	F(9)	3.968	0.76	2622	16,278
1972	700	0.48	5644	553.00	F(9)	4.521	0.76	3016	19,294
1973	845	0.58	6489	667.55	F(9)	5.188	0.76	4580	23,874
1974	799	0.55	7288	575.28	F(12)	5.764	0.76	4033	27,907
1975	679	0.47	7967	488.88	F(12)	6.253	0.76	3425	31,332
1-9 1976	294	0.27	8261	211.68	F(12)	6.464	0.76	1436	32,768
FY 1977	792	0.54	9053	570.24	F(12)	7.034	0.76	4262	37,030
1978	768	0.53	9821	552.96	F(12)	7.587	0.76	4175	41,205
1979	751	0.51	10,572	540.72	F(12)	8.128	0.76	4062	45,267
1980	575	0.39	11,147	414.00	F(12)	8.542	0.76	3182	48,399
1981	257	0.18	11,404	185.04	F(12)	8.72	0.76	1411	49,810
1982	581	0.40	11,985	443.73	F(12)W(6)	9.17	0.86	3134	52,944
1983	727	0.50	12,712	625.22	W(6)	9.79	1.49	3849	56,793
1984	682	0.47	13,394	586.52	W(6)	10.38	2.08	3659	60,452
1985	783	0.54	14,178	674.05	W(6)	11.05	2.75	4044	64,497

[a] Values for 1964-72 from John L. Meinhardt, Director of Nuclear Material Production, DOE, 10 January 1985, private communication. Values for 1973-84 are based on the assumption that the electric capacity factor is the same as the thermal capacity factor.

[b] Based on design rating of 4000 Mw_t.

[c] Assumes 0.86 g Pu (6 percent Pu-240)/Mw_td, 0.79 g Pu (9 percent Pu-240)/Mw_td, and 0.72 g Pu (12 percent Pu-240)/Mw_td.

[d] Indicates the mode of reactor operation, which depends on the refueling interval. W = weapon-grade; F = fuel-grade. Number in parenthesis indicates the nominal percentage of Pu-240.

[e] Actual values may differ because during fuel-grade mode of operation plutonium ranging in Pu-240 content from 5 percent to 19 percent is produced. In FY 1984-85 following the restart of PUREX, 6 percent Pu-240 fuel was culled from N-Reactor spent fuel in storage and processed.

[f] Figures taken from back issues of *Nucleonics Week*.

exposure time, thus doubling the rate at which targets pass in and out of the reactors. This doubles the annual target (Mark 31) fabrication effort at Savannah River and similarly increases activities at the Fernald and Ashtabula feed plants.

Hanford Production

The production history of the original eight Hanford graphite-moderated reactors from 1944 to 1971 is shown in Figure 3.1. The amount of plutonium produced by the reactors is estimated in Table 3.3.

Only one reactor at Hanford, the N-Reactor, now produces plutonium for weapons. It is supported by fuel cycle facilities that include the PUREX chemical separation plant and fuel fabrication facilities.

The dual purpose, graphite-moderated and water-cooled N-Reactor also produces steam for commercial electricity generation (see Hanford Reservation, Volume III).

Table 3.4 documents the production history of the N-Reactor. The most significant weapons production initiatives implemented at Hanford in recent years have been the conversion of the N-Reactor from the production of fuel-grade plutonium (12 percent Pu-240) to weapon-grade (6 percent Pu-240) and the restart of the PUREX processing plant. The N-Reactor underwent repairs and upgrading to state-of-the-art technology in 1981 and 1982. The conversion to weapon-grade production began in February 1982 and was completed by October, approximately five months ahead of schedule.[41] No tritium is produced in the N-Reactor nor is production contemplated.[42]

---

[41] HAC, FY 1984 EWDA, Part 4, p. 301.

[42] The N-Reactor operated in a plutonium/tritium coproduction mode of operation in 1966 and 1967; DOE, FEIS, L-Reactor Operation, EIS-0108, Savannah River Plant, May 1984, Vol. 1, p. 2-4. Because the N-Reactor is fueled with slightly enriched uranium, tritium production is limited to a coproduction mode of operation. Consequently, the maximum tritium output of the N-Reactor per Mwd of operation is significantly less than the output of a Savannah River reactor dedicated to tritium production.

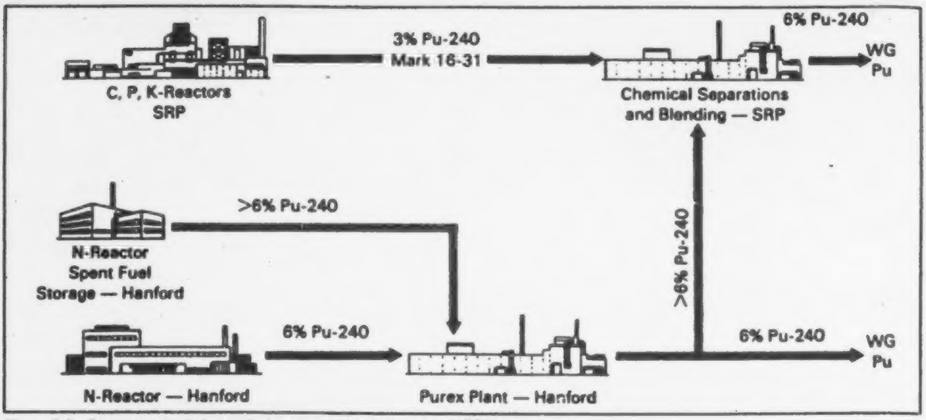

Figure 3.2 Current methods for producing weapon-grade plutonium (1984)

The N-Reactor has generally operated at a power of 3800 to 4000 Mw$_t$, producing both plutonium and by-product steam for electricity.[43] The N-Reactor produces about 600 kg of weapon-grade plutonium annually, for operation at an expected 50 percent capacity factor. In the 6 percent Pu-240 production mode, reactor operation requires the shutdown and discharge of approximately one fourth of the core of slightly enriched fuel (average 1.0 percent U-235) eight times a year.[44] Some two-and-one-half times the fuel throughput is required for weapon-grade (6 percent Pu-240) versus fuel-grade (12 percent Pu-240) plutonium production at the same capacity factor.

From the beginning of operations in December 1963, until 1973, the N-Reactor produced 9 percent Pu-240 fuel-grade plutonium part of the time. The rest of the time it produced weapon-grade (6 percent Pu-240) plutonium.[45] From 1973 to 1982, the reactor produced plutonium with a Pu-240 content of approximately 12-percent.[46] By December 1980 the N-Reactor had produced in all about 7.8 MT of fuel-grade plutonium, intended for research and development in the breeder program and other civilian activities.[47] Of this amount, about 3.6 MT had been processed at the Hanford PUREX plant before it shut down in 1972. The remaining 4.2 MT of unprocessed spent fuel was placed in storage awaiting restart of the PUREX plant.[48] By the end of FY 1984 the N-Reactor had produced in all about 8.3 MT of fuel-grade plutonium.

In FY 1981, DOE instituted its plan for blending fuel-grade plutonium at Savannah River with supergrade plutonium to increase the supply of weapon-grade material. The unseparated fuel-grade plutonium, in stored N-Reactor spent fuel, is designated for blending.[49] When PUREX was restarted, discharged N-Reactor fuel with the lowest Pu-240 content was processed first. This maximized the amount of weapon-grade plutonium available for military activities, directly or through blending.[50] In FY 1984 1046 MT of low burnup fuel was processed, producing approximately 1.0 MT of weapon-grade (6 percent Pu-240) plutonium. FY 1985 plans called for processing an additional 1200 MT of low burnup fuel for recovery of 1.2 MT of weapon-grade plutonium (6 percent Pu-240). Little, if any, of the newly recovered fuel-grade plutonium is scheduled to go into R&D. "All of the plutonium, both fuel-grade and weapon-grade, is required to meet defense program requirements."[51]

The electrical power output of the N-Reactor is 860 Mw$_e$. Through FY 1984 the N-Reactor has delivered about 60 billion kilowatt hours of electricity to the Pacific Northwest since 1966. The income to the Federal government from electricity sales was about $37 million

---

[43] The N-Reactor first reached its full design power of 4000 Mw$_t$ in December 1965: AEC, Report to Congress, January 1966, p. 78. Power was about 3850 Mw$_t$ in FY 1982: HASC, FY 1983 DOE, p. 243. At conversion, the power is 4000 Mw$_t$. In 1966 and 1967 while coproducing plutonium and tritium it operated as high as 4800 Mw$_t$ for one day (18 June 1967): DOE, FEIS, L-Reactor, Vol. 1, p. 2-4.

[44] DOE, FEIS, L-Reactor, Vol. 1, p. 1-4.

[45] Ibid.

[46] Ibid.

[47] F.C. Gilbert, DOE, in letter to Thomas B. Cochran, 24 March 1981.

[48] Ibid.

[49] "[A] significant portion of the plutonium in the N-Reactor spent fuel is reserved for defense programs; it is designated for blending . . ." Ibid.

[50] HAC, FY 1984 EWDA, Part 4, p. 308; DOE, FEIS, L-Reactor, p. 1-4. As of the end of FY 1983, about 2000 MT of N-Reactor spent fuel were in storage at the Hanford Reservation. The average Pu-240 assay of this material was around 11 percent; letter from John L. Meinhardt, Director, Office of Nuclear Materials Production, Department of Energy, to Thomas B. Cochran, 30 August 1985.

[51] HAC, FY 1984 EWDA Part 4, p. 308.

[52] DOE Memorandum, Defense Programs Accomplishments Since January 1981, DP-12, 2 July 1982.

Table 3.5

Weapon-Grade Plutonium from Reactor Production and Blending

FY	Hanford Weapon-Grade Separated[a] (kg)	Savannah River Weapon-Grade Separated[a] (kg)	Savannah River Supergrade Separated[a] (kg)	Fuel-Grade Required[e] (kg)		Weapon-Grade by Blending (kg)	Total Weapon-Grade (kg)
				Annual	Cumulative		
1982		700[d]	360[d]	180	180	540	1240
1983		240[d]	700[d]	350	530	1050	1290
1984	910[b]	0	1085	540	1070	1590	2500
1985	1050[b]	0	1055	530	1600	1585	2635
1986	650[c]	0	1345	670	2270	2015	2665
1987	650[c]	0	1635	820	3090	2455	3105
1988	650[c]	0	1570	785	3875	2355	3005
1989	650[c]	0	1525	760	4635	2285	2935
1990	650[c]	0	1435	720	5355	2155	2805

[a] Allows for 6-month cooling period of discharged fuel before processing.

[b] PUREX separated only 6 percent Pu-240 plutonium in FY 1984 (from 1046 MT uranium) and in FY 1985 (from 1200 MT uranium), culling out all of the 6 percent Pu-240 plutonium in storage and processing fuel from current production.

[c] Assumes N-Reactor operation at 4000 MW_t and 52 percent capacity factor.

[d] Assumes 20 percent of the plutonium production in FY 1981 and 50 percent of the production in FY 1982 is supergrade.

[e] This assumes blending with 12 percent (average) Pu-240 plutonium and gives an upper bound to fuel-grade requirements. Blending with 9 percent Pu-240 plutonium, for example, requires 50 percent less fuel-grade plutonium.

in 1982-83 and was expected to rise by 69 percent, to more than $60 million in 1983-84, as a result of the ten-year extension to 1993 of the contractual agreement between DOE and the Washington Public Power Supply System (WPPSS) signed in June of 1982.[52]

Figure 3.2 shows the pathways leading to the production of weapon-grade plutonium. An estimate of the net annual production of weapon-grade plutonium projected into the late 1980s is provided in Table 3.5. This table combines weapon-grade production at the N-Reactor and supergrade production plus blending at Savannah River.

The Fuel Cycles

Figure 3.3 depicts the fuel cycles for the production of plutonium and tritium at Savannah River and Hanford and the operation of the naval nuclear reactors. Shown are the basic steps in a fuel cycle: uranium ore mining and milling, uranium enrichment, uranium conversion, fuel and target fabrication, reactor operation, chemical processing, and waste storage. The fuel cycle for the Naval Nuclear Propulsion Program is included because the uranium recovered from processing of naval reactor fuel is recycled into the Savannah River production reactors.

The Savannah River Fuel Cycle. As noted previously, the Savannah River reactors are currently producing tritium in the C-Reactor and supergrade (3 percent plutonium-240) plutonium in the P, K, and L reactors. Before the transition to supergrade production began in 1981, the plutonium output was entirely weapon-grade (6 percent Pu-240).[53]

The flow of materials through the Savannah River fuel cycle depends in part on whether the reactors are producing plutonium or tritium. For supergrade plutonium production, the Savannah River reactors have operated primarily with a mixed-lattice core—that is, a core with a 50-50 mixture of HEU driver fuel assemblies (about 60 percent enriched in uranium-235) and separate depleted uranium target assemblies in which plutonium is bred.[54]

The HEU for the Savannah River fuel assemblies (Mark 16B and Mark 22) comes from four sources. In order of priority, based on the cost of recovery from spent fuel or oralloy production, these are: HEU recovered at SRP and ICPP from research reactor fuel (about 80 percent enriched), HEU recovered at ICPP from naval reactor fuel (about 78 percent enriched), HEU recovered from production reactor fuel recycled at SRP (currently about 40 percent enriched), and oralloy or its equivalent at 90 percent enrichment.[55]

---

[53] For a discussion of physical processes for the production of plutonium and tritium, see Chapter Five. The plutonium grades are based on the content of the isotope plutonium-240. Grade Percentage of Pu-240: Supergrade, 2 to 3; Weapon-grade, less than 7; Fuel-grade, 7 to less than 19; Reactor-grade, 19 or greater.

[54] In time, the reactors may change to a uniform core (one type of assembly, serving as both fuel and target) of natural or slightly enriched assemblies, giving as much as 25 percent increased plutonium productivity.

[55] HASC, FY 1983 DOE, p. 209; HAC, FY 1984 EWDA, Part 6, p. 526; Memorandum from J.S. Allender and I.M. Macafee to R.L. Cook and P.L. Roggenkamp, Savannah River Laboratory, DPST-84-420, 6 April 1984, p. 3.

3

Fuel Cycles

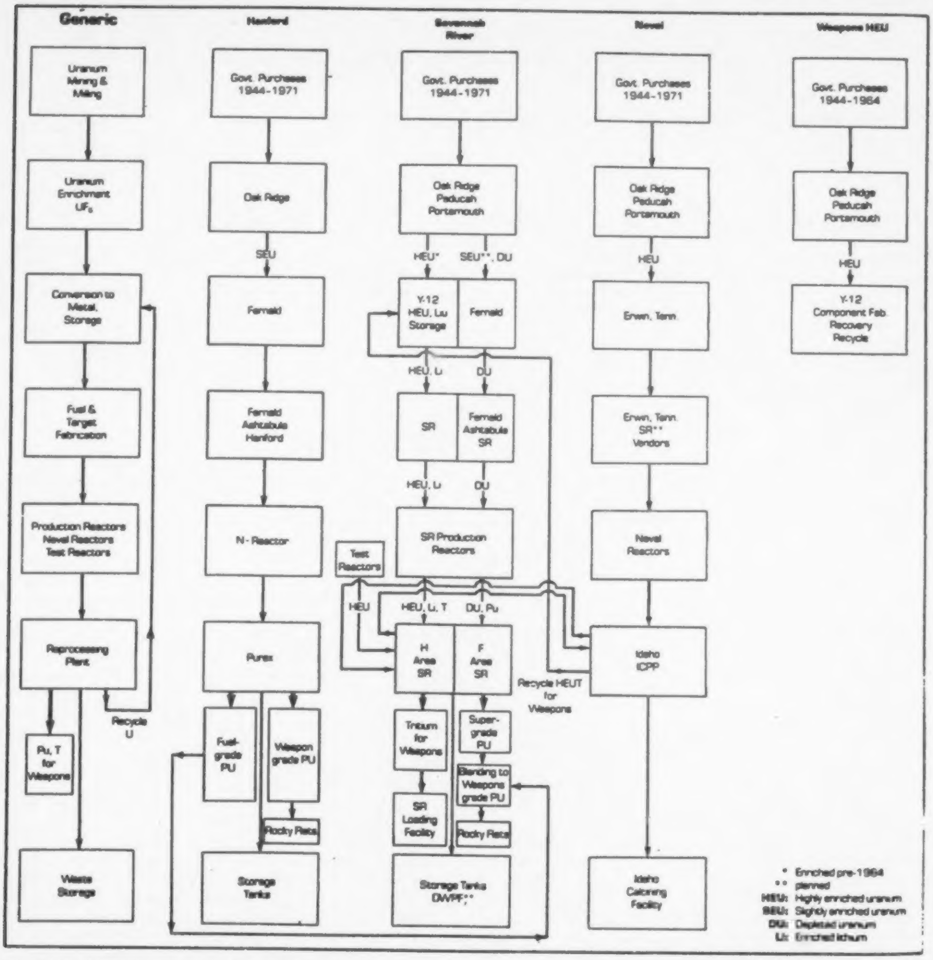

Figure 3.3 Nuclear weapons production and naval propulsion fuel cycles

The U-235 consumed in the fuel of the SRP reactors must be made up by shipments from other sources to augment SRP recycle. For the operation of four production reactors, the "make up" is about 3 MT of U-235 per year. This results from a thermal energy production of about 2350 thousand Mwd annually, and a total core loading of some 6 to 7 MT of U-235. Currently about 1 MT comes from research reactor fuel and naval reactor returns, and another 2 MT comes from the diminishing stockpile of virgin oralloy at the Oak Ridge Y-12 Plant. Beginning

Table 3.6

HEU Requirements for SRP Reactor Operation[a]

(kilograms)

Fiscal Year	SRP: Recycle + Research Reactor[b]	ICPP	Oralloy	Total
1988	9691	947	820	11,458
1989	10,046	947	1462	12,455
1990	10,970	947	2047	13,964
1991	10,957	947	1672	13,576
1992	11,194	947	1774	13,915
1993	12,435	1874	1089	15,398
1994	12,659	1874	640	15,523
1995	12,812	1874	990	15,676
1996	13,903	1874	942	16,719
1997	14,223	1874	284	16,381
1998	15,027	1874	683	17,584
1999	15,649	2859	412	18,920
2000[c]	15,649	2859	412	18,920

[a] For Mark 16-31/Mark 22 fuel assemblies: J.S. Allender and I.M. Macafee, "Economic Analysis of the Fuel Production Facility," DPST-84-420, Savannah River Laboratory, Technical Division, 6 April 1984, p. 30.

[b] Not including uranium recovered from reject fuel tubes.

[c] Assumed equal to FY 1999 throughout.

about 1988, SRP will draw oralloy from UF_6 newly enriched at the Portsmouth gaseous diffusion plant.[56] The quantities of HEU needed annually at SRP for the fabrication of fuel to support reactor operations during FY 1988-2000 are shown in Table 3.6.

The driver fuel assemblies are made of uranium-aluminum alloy at the Savannah River fuel fabrication facility. Uranium metal is shipped there from the Oak Ridge Y-12 Plant. At Savannah River it is alloyed with aluminum and extruded into aluminum-clad fuel tubes for Mark 16 assemblies. After discharge from the production reactors, the spent driver fuel elements are processed in the H-canyon, one of Savannah River's two chemical reprocessing plants, to recover HEU for recycle.[57] The HEU is shipped as uranyl nitrate by tanker trucks from the H-canyon separation plant to the Oak Ridge Y-12 plant for further processing and conversion to metal. As noted above, the metal is recycled to SRP to be made into new driver fuel elements. This happens after the recycle stream has been supplemented with virgin oralloy drawn from Y-12 stocks and HEU recovered from spent naval reactor fuel processed at the Idaho Chemical Reprocessing Plant (ICPP) at the Idaho National Engineering Laboratory (INEL); and research and test reactor fuel processed at INEL and at Savannah River. DOE is constructing a facility for producing HEU driver fuel from a mixture of highly enriched uranium oxide (U_3O_8) aluminum using techniques of powder metallurgy.[58]

The depleted uranium targets used at Savan River (Mark 31 assemblies) are fabricated from m slugs prepared at the Feed Materials Production Ce (FMPC) in Fernald, Ohio and the Ashtabula (Ohio) Ex sion Plant. They are bonded into tubular metal can Savannah River for reactor loading. Irradiated targets processed in the F-canyon, the second Savannah Ri chemical processing plant, for recovery of plutoni going into weapons, as well as recovery of depleted u nium, which is stored as oxide (UO_3) on-site.

Tritium is produced at Savannah River by irra ating lithium-6 targets. The enriched lithium is rec ered at Y-12 from components of retired warheads an alloyed with aluminum at Savannah River. Reactors loaded with a uniform core of Mark 22 assemblies co posed of alternating concentric tubes of enriched li ium-aluminum alloy and HEU aluminum alloy (75 90% U-235). Tritium is extracted from irradiated lithiu aluminum targets in H-area separation facilities a transferred to the Savannah River Tritium facility. Th it is loaded into reservoirs for subsequent insertion i weapons (see Fuel and Target Fabrication Facilities, T tium Facility, under Savannah River Plant, Volume I

An important byproduct of plutonium producti activities is the production and recovery of neptunium-237. After several recycles the concentration of U-236 in the fuel builds up. Under further irradiation the U-236 is converted to Np-237, which is recovered and fabricated into targets for Pu-238 production activities. Pu-238 is used as a heat source for the generation of electricity in reactors used in space and for other purposes. In 1968 the SR reactors changed from natural uranium fuel for plutonium production to highly enriched drivers. This increased production of U-236 and Np-237 and accelerated the Pu-238 program.[59]

---

[56] HASC, FY 1983 DOE, p. 209.

[57] Recovered uranyl nitrate liquid is shipped to the Y-12 plant for conversion to oxide. DOE is planning to close the Y-12 facility and centralize conversion operations in a new facility at Savannah River; HAC, FY 1985 EWDA, Part 4, pp. 486-492.

[58] HASC, FY 1985 DOE, pp. 167, 337.

Inventories of radioactive wastes at the SRP through 1983 include 111 thousand cubic meters (776 million curies) of high-level waste (HLW) stored in fifty-one large steel tanks,[60] 3.4 thousand cubic meters of stored transuranic waste (TRU) (98.5 kg of transuranics; 581 thousand curies), 4520 cubic meters of buried TRU (9.4 kg of transuranics; 54 thousand curies), and 414.4 thousand cubic meters of buried low-level waste (LLW) (9.57 million curies as buried).[61]

The Hanford Fuel Cycle. Fuel for plutonium production operations at the N-Reactor is fabricated from slightly enriched uranium, concentrated to an average of about 1 percent in in U-235. The principal assemblies, called Mark 1-A, are composed of an outer cylinder enriched to 1.25 percent and an inner cylinder enriched to 0.95 percent. The enriched material is now supplied directly from the gaseous diffusion plants, although in the years prior to FY 1984 it came from existing stocks at Fernald.[62] DOE Defense Programs are now rebuilding their stockpile of slighly enriched uranium hexafluoride. This stockpile became severely depleted in FY 1984.[63]

Uranium metal ingots for N-Reactor fuel are prepared at the Feed Materials Production Center (FMPC), extruded into billets at the Ashtabula Plant. The billets are simultaneously extruded and clad with zirconium at the Hanford fuel fabrication facilities. The final product is finished fuel cylinders.

In the weapon-grade (6 percent Pu-240) production mode, the N-Reactor requires about 750 to 800 MT of uranium annually, compared to 315 MT when producing fuel grade (12 percent Pu-240) plutonium. The plutonium and unused uranium is recovered from N-Reactor fuel at the PUREX separation plant. Technically, PUREX (Plutonium-URanium-EXtraction) can process up to 2300 MT of N-Reactor spent fuel. However, following restart in November 1983, it processed only 1046 MT of spent fuel in the first year, and 1057 MT in FY 1985.

The amount of fuel processed annually is expecte
to remain in this range due to limitations imposed by b
monthly inventories of the product (PuO_2) stream of tl
plant.[64]

The PUREX plant is also capable of recovering plut
nium and uranium from other low burnup, slight
enriched fuel. After the PUREX chemical processir
plant was placed on standby in 1972, batches of irrad
ated fuel were stored on-site at Hanford in water-fille
concrete basins.

The recovered fuel-grade plutonium oxide will
shipped to Savannah River for blending, while tl
weapon-grade plutonium oxide is sent to the plutoniu
facility at LANL for conversion to metal.

Chemical processing wastes from PUREX, as well
from previous processing operations (Bismuth Pho
phate and REDOX, see Hanford Reservation, Volume I
are stored on-site. The totals through 1983 include 2
thousand cubic meters of HLW (474 million curie
stored in 169 large steel tanks,[65] 12.8 thousand cub
meters of stored TRU (340 kg of transuranics; 28.4 tho
sand curies of alpha activity), 92.1 thousand cub
meters of buried TRU (350 kg of transuranics; 29.2 tho
sand curies of alpha activity), and 317.1 thousand cub
meters of LLW (5.04 million curies as buried).[66]

Naval Reactor and Research Reactor Fuel Cycle
The Naval Nuclear Propulsion Program (NNPP) is a joi
program of the Department of Energy and the Departme
of the Navy. It oversees all aspects of naval nuclear rea
tors including research, procurement, disposal, and su
plying reactor fuel. The naval fuel cycle interacts wi
the cycle that produces material for weapons. High
enriched uranium recovered from spent fuel of na
reactors is recycled to supply a part of fuel used in t
Savannah River production reactors.

In the more than thirty years of the NNPP 1
nuclear-powered ships have served in the active fleet
These ships were propelled by a total of 182 reactors. T
current fleet (as of March 1986), numbering 149, uses 1
reactors.[68] The program also operates nine reactors
eight land prototype nuclear propulsion plants. The
land prototypes are used to test reactor designs and tra
crews.

Since the *Nautilus* first went to sea more than thi
years ago, U.S. naval nuclear-powered ships ha
steamed over 65 million miles and have accumulat
2900 reactor years of operation.[69] Currently the nucl
fleet travels approximately 2.5 million miles a ye

---

[59] AEC, Report to Congress, January 1980, p. 30.

[60] Savannah River has 29 million gallons of HLW, including 3 million gallons of sludge, 9 million gallons of saltcake, and 17 million gallons of liquid; HASC, FY 1985 DOE, p. 336.

[61] DOE, "Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics," DOE/NE-0017/3, September 1984, pp. 66, 118-19, 184.

[62] HAC, FY 1984 EWDA, Part 6, p. 530.

[63] HAC, FY 1985 EWDA, Part 4, p. 435.

[64] These measures were put into effect at the beginning of FY 1985 to improve material accounting safeguards.

[65] There are 149 single shell and 20 double shell tanks. Eight additional double shell tanks are under construction (1984).

[66] DOE, "Spent Fuel and Radioactive Waste Inventories, Projections and Characteristic
DOE/NE-0017/3, September 1984, pp. 66, 118-19, 184; HAC, FY 1985 EWDA, Part 6
874.

[67] Commissioned to 30 September 1985. Includes NR-1 Deep submergence research vehi

[68] See NRDC, Nuclear Weapons Databook Working Paper, "Naval Reactors," May 198

[69] HAC, FY 1987 EWDA, Part 6, p. 1072; DOE/DOD, *A Review of the United States N
Nuclear Propulsion Program*, June 1984, p. 1. For a history see Richard G. Hewlett
Francis Duncan, *Nuclear Navy 1946-1962* (Chicago: The University of Chicago P
1974), and Norman Polmar and Thomas B. Allen, *Rickover* (New York: Simon
Schuster, 1982).

Approximately 600 fresh reactor cores have been procured through FY 1984. In 1974 there were 409 and by 1979, 508 cores procured. Refuelings have become less frequent as longer-lived cores have been developed. There were fifty-eight refuelings between 5 May 1969 and 25 February 1974, forty-two between 25 February 1974 and 24 April 1979, and five a year between 1979 and 1982.[70] The total number to December 1985 was 203.

The first core for the *Nautilus* propelled the submarine for more than two years and 62,562 miles. Modern cores last 10 to 15 years and over 400,000 miles. Refuelings are done at Portsmouth Naval Shipyard at Kittery, Maine; Mare Island Naval Shipyard at Vallejo, California; and Newport News Shipbuilding and Dry Dock Company at Newport News, Virginia.

In recent times, naval reactors have required approximately 5 MT of HEU each year.[71] Twelve percent of this goes to research.[72] Assuming approximately twenty new fuel cores procured per year, modern cores average about 200 kg of HEU each. HEU (97.3 percent U-235) is enriched at the Portsmouth plant from slightly enriched feed supplied from the Paducah plant. The HEU is shipped from Portsmouth as UF_6 to Nuclear Fuel Services (NFS) at Erwin, Tennessee. There it is converted to the chemical and physical form used in naval fuel elements. Since 1978 NFS has been the sole contractor performing this work.[73] A second facility, this one government-owned, is being built at the Savannah River Plant. Known as the Fuel Materials Facility, it is scheduled to start to make fuel in 1986 and be on line in FY 1988.[74] The amount of HEU procured for the naval program will double—to about 9.6 MT in FY 1986—to meet the needs of NFS (Erwin) and the new facility and establish a three-month working inventory for the program.

After conversion at NFS the reactor fuel is sent to either Babcock and Wilcox in Lynchburg, Virginia or UNC Naval Products in Uncasville, Connecticut for fabrication into reactor cores. Typically, it takes five to seven years between the delivery of NFS fuel to these two fabricators, and the delivery of the cores to the Navy.

Naval reactors are built by either Westinghouse or General Electric. Westinghouse supplied virtually all the reactors until the 1970s, producing 123 to date (to 30 September 1985). General Electric produces reactors for LOS ANGELES class and OHIO class submarines, and its current total is 57.

Two government-owned contractor-operated laboratories conduct research on improved nuclear propulsion plants. The DOE's Bettis Atomic Power Laboratory, Pittsburgh, Pennsylvania is operated by Westinghouse Electric Corporation, while the General Electric Company operates the Knolls Atomic Power Laboratory, Schenectady, New York.

Spent fuel cores removed from naval reactors are sent to the Idaho Chemical Processing Plant (ICPP) for HEU recovery. Over its lifetime, ICPP has recovered on average 0.28 MT of U-235 per year from naval reactor spent fuel. This amounts to about 47 kg of U-235 per reactor core, at an estimated enrichment of 78 percent U-235.[75] DOE, however, has "firm commitments" for substantially increased quantities of spent fuel from the Navy in the early 1990s.[76] A recently-started restoration project at the Idaho Chemical Processing Plant will increase the chemical processing capacity for HEU recovery from spent naval reactor fuel.

The spent fuel returns from the Navy are scheduled to double 1984 rates by 1992 and nearly double again by the year 2000 (see Table 3.6).[77] Uranium recovered at INEL is shipped to the Oak Ridge Y-12 plant to be stored or converted into metal "for reuse as fuels in the Savannah River production reactors and for use in the weapons program."[78] Alternatively, in the future naval reactor spent fuel may be disposed of directly without processing to recover uranium for reuse.[79]

The DOE processes spent fuel from U.S. and foreign research and test reactors at Idaho and Savannah River. Currently the DOE accepts only HEU fuel, with an after-irradiation U-235 content of about 70 percent.[80] Through February 1985 an estimated 19 MT of U-235 has been recovered from civilian, domestic, and foreign reactor HEU fuel (see Table 3.7). Overall, an estimated 0.5 to 0.6 MT of HEU is recovered from research and test reactors annually.[81]

The recovered uranium is shipped to Y-12 and, like the naval fuel, is recycled into driver fuel for the Savannah River production reactors.

Prior to 1982 most spent fuel returned to the United States from foreign countries was sent to Savannah River

---

[70] See NRDC, "Naval Reactors."

[71] Each year the Director of the NNPP prepares a twelve-year forecast of HEU requirements: HAC, FY 1983 EWDA, Part 6, p. 174. The charge to government agencies for enrichment services is $90 per SWU (FY 1983), $93 per SWU (FY 1984), and $96 per SWU (FY 1985); Gene Schmitt, DOE, private communication. Thus the HEU (97.3 percent U-235) purchases for naval reactors were 4.84 MT (FY 1983), 5.10 MT (FY 1984), and 4.81 MT (FY 1985) using 261 SWU/kg of HEU (97.3 percent U-235).

[72] In the matter of Nuclear Fuel Service, Inc., Erwin, Tennessee, NRC Docket No. 70-143, SNM License No. 124, 1 March 1983.

[73] Prior to 1978 the following companies also provided fuel for the NNPP: Nuclear Materials and Equipment Corporation (NUMEC), Apollo, Pennsylvania 1961-1971; United Nuclear Corporation, Hematite, Missouri, 1961-1972; Babcock and Wilcox, Apollo, Pennsylvania, 1972-1978.

[74] HAC, FY 1987 EWDA, Part 6, p. 1074; In the Matter of Nuclear Fuel Services, Inc., Erwin, Tennessee, NRC Docket No. 70-143, SNM License No. 124, 1 March 1983. The Enriched Uranium Conversion Facility, undergoing renovation at the Oak Ridge Y-12 plant, will probably be used to supply the SRP Fuel Material Facility with uranium metal for naval fuel; HAC, FY 1986 EWDA, Part 7, p. 746.

[75] J.S. Allender and I.M. Macafee, "Economic Analysis of the Fuel Production Facility," Savannah River Laboratory, Technical Division, DPST-84-420, 6 April 1984, p.5. There were 22.76 MT of U-235 recovered at INEL between FY 1953 and FY 1984. Of this approximately 13.75 MT were recovered (through February 1985) from civilian HEU fuel (Volume II, Table 8). There were 180 naval reactor refuelings to 1982 and an average of five refuelings a year between 1979 and 1982.

[76] HASC, FY 1985 DOE, p. 14

[77] Ibid., pp. 143, 165.

[78] HAC, FY 1986 EWDA, Part 4, p. 301.

[79] J.S. Allender and I.M. Macafee, p. 5.

[80] Plans are in preparation to accept low enriched research reactor fuel (less than 20 percent U-235) at Savannah River.

[81] In FY 1980 SRP recovered 0.8 MT HEU from research and test reactor fuels (nonproduction DOE fuels and fuels from industry); HASC, FY 1980 DOE, p. 732.

Table 3.7

Uranium-235 Recovered through February 1985 from HEU Fuel of Civilian, Domestic, and Foreign Reactors

Reprocessing Facility	Amount U-235 Recovered (kg)
SRP	
Domestic	3200[a]
Foreign	circa 1250[b]
Subtotal	4450
INEL	
Research, Test, and Power Reactors	
Fuel Originally Enriched more than 90% U-235	7530[c,d]
EBR 2 Fuel (60% U-235)	3400[e]
Project Rover Space Propulsion	2820[d]
Subtotal	13,750
West Valley, NY	800[e]
TOTAL	19,000

a This information is derived from Tables D.2, D.3, D.5, and D.6 in Appendix D that detail the amount of U-235 required by domestic reactors. The amount of U-235 recovered is computed by assuming that about 30 percent of the U-235 was consumed in the reactors.

b Estimated from Table 3.10.

c Letter from John L. Meinhardt, Director, Office of Nuclear Materials Production, Department of Energy to David Albright, 6 May 1985. It includes a small amount of foreign HEU.

d Using the information in Tables D.2, D.3, D.5, and D.6 in Appendix D and assuming a burnup of 30 percent, an estimated 6900 to 7650 kg of U-235 was recovered at INEL from domestic research and power reactors whose fuel was originally enriched over 90 percent U-235.

e Meinhardt, *op. cit.*, and corrections to the amount listed in the letter as recovered from EBR 2 spent fuel, INEL, personal communication, 21 May 1985.

Source: Table compiled by David Albright.

Table 3.8

Receipts of Spent Fuel from Research Reactors

Savannah River

	Domestic[a,b]		Foreign[a]	
Year	HEU (kg)	U-235 (kg)	HEU (kg)	U-235 (kg)
1976	?	?	71	46
1977	?	?	43	32
1978	176	?	379	283
1979	136	110	185	150
1980	108	70	224	160
1981	165	130	201	160
1982	158	120	200	150
1983	111	?	25	20
1984	146	?	67	?

Idaho Chemical Processing Plant

	Foreign[c]		Total[d]	
Year	HEU (kg)	U-235 (kg)	HEU (kg)	U-235 (kg)
1973			913.8	598.8
1974			623.3	357.5
1975			1237.7	1031.1
1976	?	?	3024.9	2570.1
1976T	?	?	184.8	125.4
1977	?	?	535.4	414.9
1978	2.5	0.6	288.9	200.4
1979	0	0	317.1	201.0
1980	0	0	479.3	325.7
1981	0	0	254.5	177.6
1982	82	57	766.3	541.2
1983	95	72	141.8	91.3
1984	?	?	345.4	246.5

a For 1976-78, C.E. Behrens, "Questions Concerning Spent Nuclear Fuel Entering the U.S. from Abroad," Congressional Research Service, 27 November 1979. For 1979-81, letter with attachments to T. Harris, Public Research Foundation, Columbia, SC, from R.C. Webb, Deputy Director, Office of External Affairs, DOE, Savannah River Operations Office, 22 July 1983. For 1982 and 1983, *DOE News*, Fact Sheet on Foreign/Domestic Research Spent Fuel Shipments, Savannah River Operations Office, June 1983 and February 1984.

b Domestic fuel is also received at Idaho.

c DOE, Nuclear Materials Management and Safeguards System.

d Values in these two columns are given for Fiscal Years.

for processing. Beginning in 1982 increased amounts of returned spent fuel were also routed to Idaho because of the reprocessing plant's unique capability to recover krypton, then in short supply. (Radioactive krypton is used commercially as a leak detector.) This arrangement will probably continue until 1986 when the Idaho plant will have been modified to collect krypton from the processing of naval fuel. Spent fuel from domestic research reactors is processed regularly at both Idaho and Savannah River. Table 3.8 shows receipts of foreign and domestic spent fuel at the reprocessing plants in recent years.

In the United States there are twenty-two DOE-owned research and test reactors in addition to fifty-nine research and test reactors licensed by the Nuclear Regulatory Commission (operated mainly by universities), with DOE-owned fuel. Approximately ninety-three fo eign research and test reactors operate with uranium U.S. origin. Annually, about 1 MT of HEU (90 perce enriched) is either used domestically (about 600 kg) exported (about 300 to 500 kg).[62]

Exported HEU comes from three sources: the Y- inventory, the Portsmouth gaseous plant, and the Unit Nuclear Corporation Recovery System. In the ye

---

[62] Memorandum from James R. Shea, NRC, to NRC Commissioners, 1 December 1981. In the years 1976-82 an average of 438 kg of HEU enriched to an average of 88.7 percent was exported annually for research purposes; see Table 3.6.

Table 3.9

U.S. HEU Exports and Returns by Country[a]

	Exports (kg)[b]		Returns (kg)[c]			
			Spent Fuel[d]		Total[e]	
Year	HEU	U-235	HEU	U-235	HEU	U-235
Argentina	94.11	59.15			0.06	0.02
Austria	9.75	7.32			7.05	4.57
Australia	10.19	9.16	3.4	2.3	0.06	0.05
Belgium	196.55	159.17	86.6	63.2	494.30	385.70
Brazil	7.70	7.15				
Canada	1861.49	1723.64	408.2	268.9	509.02	355.12
Colombia	3.11	2.82				
Denmark	26.21	23.55	37.9	25.9	37.86	26.70
Finland	3.86	0.77				
France	6268.41	4655.46	408.2	324.6	2411.05	1738.65
Greece	6.61	6.15				
IAEA	0.31	0.25				
India	0.10	0.08				
Indonesia	0.02	0.01				
Iran	5.55	5.16				
Israel	18.73	17.09				
Italy	382.07	306.80	12.0	9.6	45.76	36.63
Japan	2015.52	964.81	69.8	61.8	167.51	146.41
Mexico	29.63	12.32	0.6	0.4	0.57	0.40
Netherlands	63.22	56.52	105.5	80.4	149.77	115.77
Pakistan	5.76	5.18				
Philippines	3.29	3.07				
Portugal	7.66	7.14				
Romania	39.25	36.56				
South Africa	32.70	30.21	19.0	14.3	33.50	25.75
South Korea	29.61	18.47				
Switzerland	8.79	7.96			6.46	4.36
Spain	9.41	8.30				
Sweden	148.07	133.34	204.1	153.8	225.48	170.42
Taiwan	9.91	9.21				
Thailand	5.30	4.77				
Turkey	5.32	4.78				
U.K.	2301.02	2141.35	0.4	0.3	107.95	82.97
Venezuela	0.01	0.01				
Vietnam	0.39	0.08				
W. Germany	9993.65	6612.51	131.5	93.5	880.05	325.23
Yugoslavia	17.05	5.91			0.22	0.05
Zaire	1.35	0.28				

[a] Does not include HEU exported for military purposes.

[b] For 1 January 1954 through 28 February 1983. Excludes countries receiving a cumulative shipment of 0.005 kg U-235 or less. DOE, Nuclear Materials Management and Safeguards System, NMMSS Report TJ-25, 28 March 1983.

[c] U.S. origin HEU returned. In some cases returns from a country exceed exports to it because data to not reflect retransfers between foreign countries for fabrication or reprocessing of fuel.

[d] Data for 1954-81. U.S. GAO, Obstacles to U.S. Ability to Control and Track Weapons-Grade Uranium Supplied Abroad, GAO/ID-82-21, 2 August 1982, p. 15.

[e] DOE Nuclear Materials Management and Safeguards System, NMMSS Report U.S. Origin Imports, 29 November 1984, enclosure in letter to Thomas B. Cochran from Robert A. O'Brien, Jr., DOE, 13 December 1984.

1980-1983 about 40 percent was uranium metal taken from the DOE inventory at Y-12. Most of the remainder was enriched on order at Portsmouth and shipped overseas as UF_6. A small amount (about 2 percent) was material recovered by United Nuclear.[83]

From 1954 through 1983 the United States shipped abroad approximately 17 MT of U-235 as HEU for research purposes. (It is estimated that 11 MT of the U-235 was HEU-enriched to 90 percent or better.) As shown in Tables 3.9 and 3.10, about 1.5 MT was returned as spent fuel, and about 3.6 MT of U-235 was returned

---

[83] DOE, Nuclear Materials Management and Safeguards System.

Table 3.10

U.S. HEU Exports and Returns by Year

Year	Exports (kg)[a]		Returns (kg)[b]			
			Spent Fuel[c]		Total[d]	
	HEU	U-235	HEU	U-235	HEU	U-235
1954-1956	0	0	0	0	0	0
1957	26.43	24.59	0	0	0	0
1958	13.75	12.33	1.67	1.32	1.67	1.32
1959	17.74	16.18	0	0	0	0
1960	52.87	47.53	2.76	2.24	4.32	3.22
1961	264.94	212.32	2.29	1.81	3.94	2.17
1962	328.55	296.04	1.93	1.47	2.32	1.74
1963	360.88	296.20	16.18	13.49	22.08	18.92
1964	806.30	675.18	46.70	37.96	63.10	52.32
1965	2518.55	1346.92	18.86	15.59	35.50	29.51
1966	1505.22	927.71	46.23	29.42	109.77	74.81
1967	2682.06	1260.61	115.15	83.69	226.91	168.68
1968	905.27	806.72	6.02	5.09	89.89	73.52
1969	1961.78	1450.28	4.02	3.34	14.01	12.60
1970	1274.52	962.09	37.12	26.48	63.49	43.64
1971	2220.02	1358.91	49.46	38.61	441.80	340.22
1972	885.07	795.73	42.79	31.82	738.22	216.13
1973	887.75	823.03	9.07	7.90	434.87	316.85
1974	1550.67	1221.62	10.50	7.65	344.81	255.52
1975	666.14	618.72	14.59	10.94	174.37	135.57
1976	601.10	556.85	67.38	44.14	384.50	296.70
1977	1861.80	1367.99	82.32	61.80	149.00	103.56
1978	404.46	346.81	372.91	278.37	874.28	593.06
1979	361.33	336.43	168.00	128.17	217.53	167.35
1980	491.48	424.24	273.23	198.39	210.84	151.40
1981	535.03	485.51	212.30	164.70	251.42	195.74
1982	397.05	349.04	288.70[e]	207.00[f]	?	?
1983	125.00[g]	116.00[g]	120.00[h]	92.00[h]	?	?
TOTAL	23705.76	17135.58	2010.18	1493.39	ca. 5300	ca. 3600

[a] Data except for 1983 from DOE, Nuclear Materials Management and Safeguards System, NMMSS Report TJ-25, 28 March 1983.

[b] Returns of U.S. origin HEU.

[c] DOE, Nuclear Materials Management and Safeguards System, 28 March 1983.

[d] DOE, Nuclear Materials Management and Safeguards System, NMMSS Report U.S. Origin Imports, 29 November 1984; enclosure in letter to Thomas B. Cochran from Robert A. O'Brien, Jr., DOE, 13 December 1984.

[e] GAO Report to Richard L. Ottinger, "Return of Spent Nuclear Fuel from Foreign Research Reactors to the United States," GAO/RCFD-85-47, 13 December 1984.

[f] Estimated.

[g] DOE, Nuclear Materials Management and Safeguards System, 29 November 1984.

[h] DOE News Fact Sheet on Foreign/Domestic Research Fuel Shipments, Savannah River Operations Office, June 1983 and February 1984.

overall. Additional uranium was sent back to the United States following separation from DOE-owned fuel at reprocessing plants in Belgium and France, during the 1970s, and in Japan. Recently, annual returns from abroad (average 240 kg contained U-235 per year for 1978-82) have paralleled supply (assuming a fuel burnup of about 50 percent and a process loss of about 20 percent).[84]

Plutonium and Tritium Inventories

In the public domain government data is not available on the inventories of weapon-grade plutonium, tritium, highly enriched uranium, or lithium-6. T Department of Energy's inventory of fuel-grade plu nium is unclassified, and there is data on heavy wa production. Nonetheless reliable estimates of the inve tories of nuclear weapon materials can be made (s Table 3.11).[85]

These inventories include the materials actually the weapons themselves as well as material allocated the weapons program. In the case of plutonium and tium it is believed that only a small fraction is curren available as a reserve.

---

[84] Letter from Ralph E. Caudle, DOE, to Milton M. Hoenig, 23 December 1982.

[85] An early estimate of the U.S. inventory of nuclear materials is given by Marvin I. Kalkstein and Winthrop Smith, "An Estimate of the Nuclear Stockpile from Unclassified Sources," in *Arms Reduction Program & Issues*, David H. Frisch, ed., (New York: The Twen Century Fund, Inc., 1961).

Table 3.11

Nuclear Materials Inventories and Production

(End FY 1984)

Material	Inventory	Annual Production
Plutonium		
Weapon-Grade	93 ± 7 MT	2.5 MT[a]
Fuel-Grade	15.5 MT	None[b]
Tritium	70 ± 25 kg	10.7 kg[c]
Uranium		
HEU metal	approx. 500-530 MT	None[d]
Lithium-6	greater than 390 MT	None
Deuterium	740 ± 20 MT as heavy water[e]	None

a With startup of the L-Reactor this increases to some 3 MT by FY 1987; see Table 3.5.

b The inventory is decreasing by 0.5 MT per year (FY 1985); 0.6 (FY 1986); 0.8 (FY 1987-90); see Table 3.5.

c Tritium production is projected to increase to about 19 kg by FY 1991 and then decrease to about 10 kg annually by the late 1990s; see Table 3.2.

d New production planned for FY 1988-90.

e 3700 MT heavy water (D2O). Of this, 525 MT is in storage, 1100 is in four Savannah River reactors, and 2075 MT is allocated for weapons and other purposes (including losses).

Table 3.12

U.S. Weapon-grade Plutonium Inventory

(End FY 1984)

8 Hanford Reactors	49.1 ± 2.0 MT[a]
5 Savannah River Reactors	
Total Pu (equivalent)	59.8 ± 5.9[b]
Tritium (Pu equivalent)	-13.7 ± 2.9[c]
Other Isotopes (Pu equivalent)	-1.4 ± 1.0[d]
Subtotal SRP Production	44.7 ± 6.6
N-Reactor (since October 1982)	1.7 ± 0.2[e]
Additions through Blending	1.0 ± 0.2[f]
Subtotal Production	96.5 ± 6.9 MT
Losses	
Reprocessing (0.5%)	-0.5 ± 0.5
Weapon Tests (3.0%)	-2.9 ± 1.0
Subtotal Losses	-3.4 ± 1.1
TOTAL INVENTORY	93.1 ± 7.0 MT[g]

a From Table 3.3.

b From Table 3.2. Assumes 6-month cooling period.

c Based on cumulative production of 190 kg tritium of which 70 kg was produced in control rods (see Table C.1 in Appendix C). One kg of tritium production equivalent to 72 kg of plutonium production.

d Assume to be 1 percent of total production plus approximately three years of small core operation based on authors' calculations.

e From Tables 3.4 and 3.5

f From Table 3.4.

g Excludes weapon-grade plutonium that may have been received from the United Kingdom under the Mutual Defense Agreement of 1958. It is conjectured that 0.78 MT weapon-grade plutonium may have been received from UK military reactors: See R.V. Hesketh, "Nuclear Power UK, Nuclear Weapons USA," Evidence on behalf of CND in the Sizewell "B" Inquiry, September 1984, pp. 42, 85; and 0.36 MT from civil reactors: see K.W.J. Barnham, D. Hart, J. Nelson and R.A. Stevens, "The Production and Destiny of British Civil Plutonium," *Nature* 317 (19 September 1985): 213-17.

Weapon-grade Plutonium. The stockpile of weapon-grade plutonium accumulated from the Savannah River and Hanford production reactors is estimated to be 93 ± 7 MT as of the end of FY 1984 (see Table 3.12). The principal sources are the 49 ± 2 MT from the original eight Hanford reactors (see Table 3.3) and 45 ± 7 MT from the Savannah River reactors (see Table 3.2 and Table 3.12). Some losses have occurred during reprocessing and tests. By the end of FY 1990 the weapon grade plutonium inventory is expected to reach 110 MT.[86]

Fuel- and Reactor-grade Inventories. In addition to the stockpile of weapon-grade plutonium produced specifically for weapons, DOE's Defense Program also has jurisdiction over some 16 MT of mainly fuel-grade plutonium (7-19 percent Pu-240) and an additional 0.8 MT of reactor-grade plutonium (>19 percent Pu-240) that has been accumulated over several decades.

The stocks of these materials might be legitimately referred to as "military" and "civil" inventories, depending on their original or intended use. Traditionally the fuel-grade inventory has been the source of plutonium for the U.S. breeder research reactor program and other non-defense activities.[87] Some of this material is in unseparated spent fuel. The remainder has been either unallocated or loaned to DOE civilian research and development programs. Since 1981, weapons program demands have diverted fuel-grade plutonium from potential civilian use to blending for weapons use. Plans also call for the eventual purification of the remainder in a plutonium isotope separation plant starting in the early 1990s.

The single largest source of fuel-grade plutonium is the N-Reactor at Hanford. From the start of operation in 1963 until conversion to weapon-grade production in October 1982, it produced about 8 MT of fuel-grade plutonium.[88] About half of this was separated prior to 1972, when the PUREX plant was placed on standby. The rest was processed after the recent restart of the PUREX facility. The remainder of the fuel-grade inventory was built

---

[86] See Table 3.5.

[87] See Cochran, Briefing Session.

[88] "As of December 1980 the N-Reactor is estimated to have produced about 7.8 MT of fuel-grade plutonium since operation began in 1963"; letter from F.C. Gilbert, Acting Deputy Assistant Secretary for Nuclear Materials, DOE, to Thomas B. Cochran, 29 March 1981. At the end of FY 1980, 4.2 MT of fuel-grade plutonium resided in unprocessed N-Reactor spent fuel; DOE Materials Management Plan, FY 1981-1982, Table D.2.

Table 3.13

Inventory of Fuel-grade and Reactor-grade Plutonium

Metric Tons of Plutonium

	30 Sept 1980[a]	30 Sept 1981[b]	
	Fuel-grade	Fuel-grade	Reactor-grade
Product (separated)	4.0	3.5	0.2
N-Reactor Fuel (unseparated)		4.7	
Nonproduction Reactor Fuel (unseparated)	5.5	0.8	0.2
Scrap (separated)[c]		0.6	
R&D Programs (separated)[d]	7.6[e]	7.6	0.4
TOTAL	17.1[f]	17.0	0.8

[a] Letter from F.C. Gilbert, DOE, Acting Deputy Assistant Secretary for Nuclear Materials, to Thomas B. Cochran, 24 March 1981. Does not include any plutonium that has been exported to other countries. Inventory values for 31 December 1978 are found in HAC, FY 1980 EWDA, Part 7, p. 2638.

[b] Letter from John J. Jicha, Jr., Director, Production Operations Division, Office of Nuclear Materials Production, DOE, to Thomas B. Cochran, 19 April 1982.

[c] In addition, DOE expects to recover all fuel-grade plutonium scrap expected to be available through FY 1992; letter from F.C. Gilbert, DOE, 24 March 1981.

[d] An estimated 0.3 MT of weapon-grade plutonium was in DOE nondefense R&D programs in February 1981; *ibid.*

[e] Another reported value for end-of-year FY 1980 is 7.15 MT fuel grade plutonium; DOE Materials Management Plan, FY 1981-92, Table D.3.

[f] As of 30 September 1980 the fuel-grade plutonium had the following status: The separated product was not yet allocated but was reserved for authorized activities in both defense and non-defense programs, and a significant portion of the unseparated plutonium in N-Reactor spent fuel was reserved for defense programs through blending in the future after PUREX processing; *ibid.*

up "from the acquisition of material from many sources over the last forty years—for example, from commercial reactor fuel reprocessing operations (West Valley, New York), the accumulation of material from other U.S. government reactor operations, material obtained by barter, and donations from firms and foreign governments."[89]

Tables 3.13 and 3.14 give several accountings of the quantity of plutonium in the fuel-grade inventory and its status, whether "separated" in a processing plant from the irradiated fuel in which it was produced or still "unseparated." As of 30 September 1981, the inventory consisted of 17.0 MT of fuel-grade and 0.8 MT of reactor-grade plutonium; in addition, there were some 0.3 MT of weapon-grade plutonium in DOE non-defense R&D programs.[90] In the year and a half before 31 March 1983, the fuel-grade inventory dropped 870 kg to a total of 16,130 kg. This resulted from withdrawals for blending at Savannah River and additions of fuel-grade plutonium inventory from further production at the N-Reactor and scrap recovery. While the N-Reactor underwent conversion to a full weapon-grade plutonium production (October 1982), both weapon-grade and fuel-grade plutonium were discharged.[91] The fuel-grade plutonium produced was a few hundred kilograms at most.

The DOE plutonium in non-defense R&D, 7.6 MT of fuel-grade and 0.8 MT of reactor-grade plutonium, is used principally by the breeder reactor program in fuel research and development; in the mixed-oxide fuel of the Fast Flux Test Facility (FFTF) at Hanford; and in the fuel plates or "coupons" for the Zero Power Plutonium Reactor (ZPPR), a critical facility at INEL. FFTF fuel contains just over 2.9 MT of fuel-grade plutonium (nominal 12 percent Pu-240) in approximately four core loadings[92] fabricated in the 1970s by the Kerr McGee Corporation. This should cover operation through most of the 1980s. Plans are to fabricate additional fuel in the late 1980s (at the Los Alamos plutonium facility), withdrawing the needed plutonium from the stockpile. The ZPPR Project contains a total of 3.8 MT of plutonium, consisting of 3.4 MT fuel-grade, 0.2 MT weapon-grade, and 0.2 MT reactor-grade.[93]

In early 1983, the schedule for converting fuel-grade plutonium for weapons use was tentatively set at blending 4 MT through the end of the decade and then enriching the remaining 11 MT by laser isotope separation in a Hanford plant.[94]

Some 4 MT of the fuel-grade plutonium now in DOE R&D facilities, mainly in the fuel of ZPPR and FFTF, was obtained in the 1960s by barter from the United Kingdom under the Mutual Defense Agreement of 1958, the United States received the material in return for highly enriched uranium and tritium. The potential use of the bartered plutonium in weapons has brought attention to some aspects of the exchange;[95] because of its origin in civil

---

[89] *Ibid.* During West Valley operation (April 1966 to December 1971), 1884 kg of plutonium were recovered including 553 kg from N-Reactor irradiated fuel; Gene I. Rochlin, et al., *Bulletin of the Atomic Scientists* (January 1978): 23.

[90] Letter from F.C. Gilbert, DOE, to Thomas B. Cochran, 24 March 1981.

[91] Letter from John J. Jicha, DOE, to Milton M. Hoenig 11 August 1982. The inventory of weapon grade plutonium in N-Reactor spent fuel is about 140 kg; *ibid.*; or 400 kg, letter from Donald Paul Hodel, Secretary of Energy, to Richard L. Ottinger, 30 August 1983.

[92] Letter from Donald Paul Hodel, Secretary of Energy, to Richard L. Ottinger, 30 August 1983, Encl., p. 5.

[93] Letter from Donald Paul Hodel to Richard L. Ottinger, 5 March 1984, Encl. 1, p. 3.

[94] HAC, FY 1984 EWDA, Part 6, p. 350, p. 384; HASC, FY 1984 DOE, p. 180.

[95] Milton R. Benjamin, *International Herald Tribune* (19 March 1984): 1.

Table 3.14

Inventory of DOE Fuel- and Reactor-grade Plutonium

(31 March 1983)

Fuel-grade Plutonium[a]			
Separated	9780.0 kg	Defense Uses	285.0 kg
Unseparated	6350.0 kg	Nondefense Uses	7115.0 kg
Total	16,130.0 kg	Not Allocated[b]	8730.0 kg
		Total	16,130.0 kg

Reactor-grade Plutonium[c]			
Separated	505.0 kg	Defense Uses	0.0
Unseparated	205.0 kg	Nondefense Uses	400.0 kg
Total	710.0 kg	Not Allocated[d]	310.0 kg
		Total	710.0 kg

[a] Locations: Los Alamos National Laboratory, Mound Laboratory, Argonne National Laboratory, Brookhaven National Laboratory, Savannah River Plant, Oak Ridge National Laboratory, Hanford Site, Idaho National Engineering Laboratory, Lawrence Livermore National Laboratory; *ibid.*

[b] Not allocated for immediate use but planned for use pending clarification of definitive requirements; *ibid.*

[c] Locations: Los Alamos National Laboratory, Battelle Memorial Institute, Argonne National Laboratory, Savannah River Plant, Oak Ridge National Laboratory, Hanford Site, Idaho National Engineering Laboratory, Nevada Test Site; *ibid.*

[d] Not allocated for immediate use but planned for use pending clarification of definitive requirements; *ibid.*

Source: Letter from Donald Paul Hodel, Secretary of Energy, to Richard L. Ottinger, 5 March 1984.

reactors[96] assurances were given in 1964 by the United States that it would not be used for weapons purposes.[97]

Table 3.5 shows the quantities of fuel-grade plutonium estimated to be required for blending to produce weapon-grade material. Four metric tons will probably be used by about 1989. The table is based on projections for the annual production of supergrade plutonium at Savannah River, an activity that will be in competition with the production of tritium. After 1989 the remaining inventory of fuel-grade plutonium will be converted to weapon-grade either by blending or laser isotope enrichment, contingent on the latter program's progress.

Tritium Inventory. The best estimate of the tritium inventory as of the end of FY 1984 is 70 kg with an uncertainty of ± 25 kg (see Appendix C). Based in part on an analysis of atmospheric releases of tritium from SRP, some 140 to 200 kg of tritium has been produced (with an uncertainty of ± 60 kg) since production began in the mid-1950s. Much of this has been lost through radioactive decay (tritium decays at a rate of 5.5 percent per year). In addition, very small quantities have been sold commercially and used in research (see below), and the supply in weapons must be replenished periodically.

During the period from 1973 through 1981, tritium was produced in control rods, targets, and blankets as an adjunct to plutonium production. If this production was intended solely to offset radioactive decay, thereby maintaining the inventory at a constant level, that inventory would have been 40 kg (see Appendix C). With the subsequent increase in production it would have grown to approximately 63 kg.

Estimates of the growth of the tritium inventory are based on the projected requirements for tritium production in the 1984 Nuclear Weapons Stockpile Memorandum. Table 3.15, assuming that the FY 1984 inventory is 70 kg, shows subsequent tritium inventory estimates.

Nonweapon Uses and Sources of Tritium

Tritium produced at Savannah River is also both made available for commercial use and used by DOE's fusion R&D programs. Distributed by the Oak Ridge National Laboratory, some 0.5 kg per year is supplied for self-illuminating signs and other commercial purposes. The present tritium requirement of the magnetic fusion program is on the order of tens of grams annually.[98]

In the Magnetic Fusion Engineering Act of 1980, Congress called for the construction of a demonstration fusion power reactor by the year 2000.[99] Subsequently, the program was slowed by budget cuts and its goal made less ambitious.[100] Two competing magnetic confinement concepts, the Tokamak and the magnetic mirror, were under development. The Tokamak Fusion Test Reactor (TFTR) at Princeton University, was completed in

---

[96] Hansard, Written Answers, 27 July 1982, c. 438.

[97] ACDA, Documents on Disarmament 1964, p. 171.

[98] The Tritium Systems Test Assembly at LANL was first tested in June 1984 using 10.3 grams of tritium; LANL "Los Alamos Newsbulletin," 27 July 1984, p. 1. The on-site inventory has been estimated at 130 grams; Physics Today (November 1982): 18.

[99] Heat would be produced by the fusion of D-T fuel in a high temperature plasma of ionized atoms confined to the reactor's interior by a magnetic field.

[100] Science (2 November 1984): 525.

Table 3.15

Inventory of Tritium

(FY 1984-99)

FY	Tritium Inventory (kg)[a]
1984	70
1985	76
1986	81
1987	86
1988	92
1989	99
1990	108
1991	120
1992	130
1993	137
1994	145
1995	154
1996	160
1997	161
1998	162
1999	163

[a] Assumes tritium inventory at the end of FY 1984 is 70 kg (see Appendix C). Annual tritium production to meet requirements projected in the 1984 Nuclear Weapons Stockpile Memorandum are calculated in Table 3.2 based upon data presented in J.S. Allender and I.M. Macafee, *Economic Analysis of the Fuel Production Facility*, DPST-84-420, Savannah River Laboratory, Technical Division, 6 April 1984, pp. 5, 24.

1983.[101] The first D-T burn was scheduled for 1986[102] but has now been delayed a few years due to budgetary constraints. The Mirror Fusion Test Facility-B (MFTF-B) at LLNL is to be completed in FY 1986, but funding to operate the project may be deferred.[103] Should the program proceed to the development of commercial prototype machines the future tritium requirement is not expected to exceed one kilogram annually or about 25 kg total.[104]

Tritium may be available commercially from Canada by the late 1980s when it could be recovered in quantity from the heavy water of CANDU power reactors. Canada's Ontario Hydro is considering building a tritium recovery plant at Darlington.[105] The $150 million plant, scheduled for operation in April 1987, is designed to process 350 kg/hour of tritiated heavy water,[106] producing up to 2.5 kg of tritium annually.[107] The commercial demand in the West is between 0.5 and 1.0 kg annually.

The Production of Uranium

Uranium is a slightly radioactive metallic element (atomic number 92; atomic weight 238.07), discovered by the German chemist H.M. Klaproth in 1789. As found in nature uranium is a mixture of three isotopes: U-234 (0.01 percent), U-235 (0.711 percent), and U-238 (99.288 percent).[108] Only in the last forty years has uranium developed from a commodity of minor commercial use to one vital for both nuclear weapons and nuclear power.

In the peak weapon production years 1955-1967, the United States manufactured some 30,000 nuclear warheads. To meet material requirements for these warheads, the AEC fostered the growth of a commercial uranium mining and milling industry by buying uranium ore and concentrate (U_3O_8), and by building three huge uranium enrichment plants based on the gaseous diffusion technology. By the end of FY 1964 the AEC had produced on the order of 700 MT of highly enriched uranium (HEU), most of which was converted to metal, or oralloy, for use in weapons.[109] While most of this oralloy was indeed used in weapons, the AEC also had unused stocks when production of HEU metal was halted.[110]

Since 1967, the number of weapons and their yields have decreased, and the AEC (now DOE) has been able to meet its requirements for HEU metal from existing supplies. During this period all HEU for new weapons came from material recovered from retired weapons, and it was unnecessary to draw down the oralloy stocks at the Y-12 plant.[111] Some of the oralloy inventory, however, has been used to supply a portion of the fuel for the SRP production reactors, as well as fuel for some DOE and foreign research and test reactors.

Demand for HEU is increasing. The U.S. weapon stockpile is growing once again, newer warheads have a

---

[101] The TFTR system had its first test at 3:06 a.m., 24 December 1982, successfully heating hydrogen gas and generating a plasma lasting 50 thousandths of a second.

[102] Walter Sullivan, *New York Times*, 29 December 1982, p. 1. The first D-T fusion tests are scheduled for 1986, and the tritium inventory would be only five grams. LANL, "Los Alamos Newsbulletin," 27 July 1984, p. 1.

[103] Science (2 November 1984): 525.

[104] STARFIRE, a 1200 MWe (3510 MW heat) Tokamak power plant designed by Argonne National Laboratory, would have an inventory of about 12 kg of tritium; Argonne National Laboratory, "STARFIRE—A Commercial Tokamak Fusion Power Plant Study," ANL/FPP-80-1, September 1980. Subsequent designs that suggest significant reductions in the inventory are possible. Reactors, after the initial tritium loading, could produce all the tritium needed by neutron absorption in surrounding lithium blankets.

[105] *Nuclear Engineering International* (June 1983): 32-33. Plans for a second plant at Pickering have been canceled. The Darlington plant is being designed by Sulzer Brothers of Winterthor, Switzerland. The Canadian plant will be essentially a scaled-up version of the tritium removal system suppplied by Sulzer for the high flux reactor operated by the Lave Langevin Institute at Grenoble, France.

[106] Ontario Hydro has over 8 GW_e installed nuclear capacity and another 8 GW_e planned, all based on heavy water-moderated CANDU reactor technology. During normal operation the heavy water moderator becomes tritiated by neutron absorption.

[107] *Nucleonics Week* (8 November 1984): 11. See also *Nuclear Engineering International* (June 1983): 32 and *Nucleonics Week* (31 March 1983): 9.

[108] John F. Hogerton, *The Atomic Energy Deskbook* (New York: Reinhold Publishing Corporation, 1963), p. 578. The concentrations are given in weight percent.

[109] "Oralloy" is the name used for U-235, or highly enriched uranium (93.5 percent U-235) metal for weapons. The name, which derives from *Oak Ridge Alloy*, was a code word used during the Manhattan Project.

[110] Long Range Nuclear Weapons Planning Analysis for the Final Report of the DOD/DOE Long Range Resource Planning Group, 15 July 1980, p. 73. The Enriched Uranium Conversion Facility at the Oak Ridge Y-12 plant, used to convert enriched UF_6 to UF_4, was placed on standby in FY 1984; HAC, FY 1985 EWDA, Part 4, p. 508. On 20 April 1964 President Johnson announced that he had ordered further reductions in the production of enriched uranium to be carried out over a period of four years. Added to previous reductions it meant a decrease of 40 percent. On the same day Premier Khrushchev announced that the Soviet Union would stop construction of two plutonium production reactors, reduce the production of U-235 for weapons, and allocate more fissionable materials for peaceful uses; ACDA, *Documents on Disarmament 1964*, pp. 165-68.

[111] HASC, FY 1985 DOE, p. 115-16; by FY 1982, for example, 100 percent of the HEU recovered from retired weapons was recycled for new weapons; HASC, FY 1982 DOE, pp. 35, 172; HAC, FY 1985 EWDA, Part 6, p. 859. The projected supply of highly enriched uranium shown in the FY 1984-89 Nuclear Weapons Stockpile Memorandum includes material from weapons scheduled for retirement "plus the existing Y-12 Plant inventory." Ibid., p. 860.

Table 3.16

AEC Domestic Uranium Ore Purchases

(FY 1949-62)

	At Buying Stations		Under Special Arrangements		Total	
FY	Tons of Ore	Pounds U_3O_8	Tons of Ore	Pounds U_3O_8	Tons of Ore	Pounds U_3O_8
1949	28,742	126,302	-	-	28,742	126,302
1950	65,602	351,152	-	-	65,602	351,152
1951	55,904	363,663	-	-	55,904	263,663
1952	87,191	445,725	1,300	4,713	33,491	450,438
1953	121,015	707,581	48,960	232,181	169,975	939,772
1954	267,510	1,601,241	110,515	698,248	378,025	2,299,489
1955	480,232	2,922,826	126,853	962,490	607,085	3,885,316
1956	753,595	4,347,465	52,303	280,677	805,898	4,628,142
1957	587,495	3,778,372	17,016	97,921	604,511	3,876,293
1958	220,649	1,163,049	1,507	5,934	222,156	1,168,983
1959	138,596	1,531,374	734	3,806	139,330	1,535,180
1960	113,345	1,099,928	31,634	148,236	144,979	1,248,164
1961	41,465	453,773	179,966	922,201	221,431	1,375,974
1962	30,408	265,601	60,351	332,210	90,759	597,811
Totals	2,991,749	19,058,052	631,139	3,688,627	3,622,888	22,746,679

The second and third columns represent ore purchased at eleven different ore-buying stations operated for varying lengths of time in the western United States by AEC between 1948 and 1962. The fourth and fifth columns show ore bought under special arrangements with mills and the AEC ore-buying agent to purchase ore in certain areas for a limited time and usually while mills were under construction. All of the 3,622,888 tons of ore bought during this period was gradually sold to the mills. By the end of 1960 there were 1.3 millions tons or ore held in government stockpiles; at the end of December 1966, the AEC had no ore stockpiles. The eleven AEC ore-buying stations were at Globe and Tube City, Arizona; Edgemont, South Dakota; Grants and Shiprock, New Mexico; Marysvale, Moab, Monticello, and White Canyon, Utah; and Crooks Gap and Riverton, Wyoming. The last AEC station, at Monticello, Utah, was closed on 31 March 1962, with the termination of the Domestic Uranium Program Circular 5, Revised.

Source: DOE, "Statistical Data of the Uranium Industry," Grand Junction Area Office, GJO-100(83), 1 January 1983, p. 71.

higher yield to volume, and production reactors continue to draw on the oralloy inventory for part of their fuel requirements. As a consequence, DOE plans to call for the resumption of oralloy production in FY 1988-90 with "a potential for a substantial increased requirement for highly enriched uranium".[112]

Uranium Mining and Milling

To meet military needs in the early 1940s, the Manhattan Engineer District obtained uranium ore from the rich pitchblendes (greater than 10 percent equivalent in the uranium oxide U_3O_8) of the Belgian Congo and the Great Bear Lake, Canada. These deposits were supplemented by production from a few small mines in the Colorado Plateau area. These high-grade ores and concentrates were refined by an ether extraction technique adapted from analytical chemistry procedures. The processes used for low-grade ores were relatively crude and reflected little change from methods used at the turn of the century. Milling costs were high and uranium recovery was relatively inefficient.

After the Atomic Energy Act of 1946 went into effect, the AEC placed strong emphasis on the discovery and development of new sources of uranium in the United States. It also encouraged development of improved processing techniques to satisfy renewed military demands.[113] Major domestic sources of uranium were found in flat-lying deposits in sedimentary rock—principally sandstone—in the western states. In April 1948 the AEC initiated a program of incentives that included price guarantees and bonuses for discovery and delivery in order to spur exploration and production. The response was so great that the government was able to terminate domestic ore purchases in 1962 and slow concentrate purchases until terminating them in 1970. Between 1949 and 1962 the AEC purchased some 3.6 million short tons of uranium ore, containing 11,373 tons of U_3O_8 (see Table 3.16).

Contracts to process the ore were negotiated with private industrial concerns. The end product of this activity was uranium concentrate, mainly uranium oxide

---

[112] HASC, FY 1985 DOE, pp. 115-16; Renovation of the Enriched Uranium Conversion Facility at the Y-12 plant facility is scheduled for completion in the spring of 1988; HAC, FY 1985 EWDA, Part 4, p. 503; quote from HAC, EWDA, FY 1986, Part 7, p. 884.

[113] Wartime control over uranium exercised by the War Production Board was continued by the Office of Temporary Controls until AEC took control of source material on 31 March 1947; AEC, Report to Congress, July 1947, p. 2.

Currently Brush-Wellman, Inc. of Elmore, Ohio (formerly Brush Beryllium) is the only large United States commercial producer of beryllium concentrates. Low-grade bertrandite ore mined in Utah is the major commercial source of beryllium ore. Imports of beryl, a silicate of beryllium and aluminum ($3BeO \cdot Al_2O_3 \cdot 6SiO_2$) augment the domestic supply of ore concentrates, and there is a small domestic output of beryl.

Brush-Wellman converts both beryl and bertrandite ore to beryllium at its plant in Delta, Utah. The company has initiated a program to stimulate domestic and foreign beryl mining, to make use of its beryl ore processing capacity. Brush-Wellman plans to modify the Delta plant by mid-1983 to process lower grade beryllium ore.[165] The company uses the Sawyer-Kjellgren process to produce reactor-grade metal and beryllium oxide (BeO) from beryl. Domestic production consists of beryllium metal, beryllium oxide, and beryllium-copper master alloy.[166]

The Cabot Berylco Division (formerly Kawecki-Berylco Industries, Inc.) of the Cabot Corporation produces beryllium-copper and other beryllium alloys at its plant in Reading, Pennsylvania. The plant uses imported and domestic ores that have been converted to beryllium oxide.[167]

In 1980 the manager of the Albequerque Operations Office, testified, "Only one company [probably Brush Wellman] in the U.S. manufactures beryllium to DOE specifications. Previously there were two."[168]

The projected weapon requirements for beryllium were set out in 1979 by the Assistant Secretary for Defense Programs: "If we look at the requirements through 1986 which are in the present stockpile paper . . .; our estimate is it will require about 125,000 pounds of beryllium oxide to fulfill the need of that stockpile."[169]

Beryllium is inventoried by the government for the National Defense Stockpile of strategic materials. Holdings as of 31 March 1984 are 18.0 tons of beryl ore (11 percent Be), 7.4 tons of beryllium copper master alloy, and 229 tons of beryllium metal.[170]

Other Non-nuclear Materials. Gold, a metal used in nuclear weapons, is purchased by the government on the open market. In addition to gold and beryllium, other non-nuclear materials that might be incorporated into nuclear warhead components—aluminum, chromium, nickel, tin, titanium, and tungsten—are acquired by the government as part of the National Defense Stockpile inventory of strategic and critical materials.

Initiatives to Increase Production

The Carter administration began plans to upgrade the nuclear weapons production complex. These plans have given rise to several initiatives to increase the production of nuclear materials, principally plutonium and tritium. President Carter bequeathed to President Reagan an accelerated set of warhead production goals. These were contained in Carter's last NWSM, signed on 20 October 1980, and in his FY 1982 budget request. Upon entering office, Reagan provided an FY 1982 budget of his own, increasing the DOE Defense Programs request by almost $300 million, to just over $5 billion. The materials production budget, alone, increased from $837 million to $931 million.[171]

The Reagan administration, in addition to taking on Carter administration production accelerations, also added new requirements. In August 1981 Reagan announced that enhanced radiation weapons would be produced, reversing the Carter moratorium. On 2 October 1981, President Reagan unveiled his five-part strategic weapons modernization program.[172] Reagan's first NWSM, signed on 17 March 1982, called for a different mix of weapons that, coupled with certain technological developments, drove materials production requirements even higher. Smaller size weapons with higher yield-to-weight ratios required more plutonium per weapon. And additional supplies of tritium would be needed for enhanced radiation weapons.

Reagan's second Stockpile Memorandum, signed 18 November 1982, reinforced production goals. In approving the NWSM, he had declared that, ". . . as a matter of national policy, . . . [a]rbitrary constraints on nuclear materials availability . . . shall not be allowed to jeopardize attainment of the forces required to assure our defense and maintain deterrence."[173] This memorandum included, apparently, a plan to create "sufficient reserves" of special nuclear material (SNM),[174] needed "as insurance against unforseen SNM production interruptions and to allow for surge capacity."[175] The required plutonium "reserve" was set at some 5 MT. By the time Reagan's third NWSM was signed on 16 February 1984,[176] plans to build up the inventory of HEU had also been established, signalling a move to increase the yield of new warheads.

The size of the U.S. nuclear weapons stockpile has increased slightly since 1982. As a DOE official stated in March 1983, the number of weapons in the stockpile was expected to increase by 13 percent by the end of FY

---

material was sold directly from DOE inventories in FY 1982 and FY 1983; Readus Long, GSA, private communication.

[162] At 100 percent efficiency, this would provide a fusion yield of about 30,000 Mt.

[163] The W33 gun assembly type warhead, which has been in the stockpile since 1956, uses a polonium-beryllium neutron initiator.

[164] AEC, Report to Congress, January 1956.

[165] Benjamin Petkof, "Beryllium," 1981 Bureau of Mines Minerals Yearbook Preprint, U.S. Department of the Interior, 1981, p. 1.

[166] Ibid.

[167] Ibid.

[168] HASC, FY 1981 DOE, p. 164.

[169] HASC, FY 1980 DOE, p. 208.

[170] FEMA, Stockpile Report to the Congress, October 1983-March 1984, October 1984, p. 23.

[171] Comparison of the Carter Budget justifications in HAC, FY 1982 EWDA, Part 6, with Reagan's in HAC, FY 1982 EWDA, Part 5.

[172] For an extensive discussion see SASC, Strategic Force Modernization Programs, Hearings and SASC, Modernization of the U.S. Strategic Deterrent Hearings.

[173] DOE, FEIS L-Reactor, Vol. 1, p. 1-2.

[174] DOD, FY 1984 Annual Report, p. 277. There was no mention of a reserve the year before.

[175] Office of the Assistant to the Secretary of Defense (Atomic Energy), The Nuclear Weapons Production and RD&T Complex—DOE Support of DOE Requirements, December 1982, p. 2. See also HASC, FY 1984 DOE, pp. 126-27.

[176] HAC, FY 1985 EWDA, Part 6, pp. 334-35, 781.

1988.[177] Nonetheless, technical problems in production, funding constraints, and political controversy over certain warheads have held back these projections significantly.

Increased production trends are reflected in the budgets for materials production and in the increased employment in the production complex. The budget for materials production has gone from $506 million in FY 1980 to $1.741 billion in FY 1985.[178] In just these three years employment has grown at materials facilities from 9700 in FY 1981 to 21,400 in FY 1984.[179]

A number of initiatives designed to increase the amounts of plutonium and tritium, and HEU available for the weapons program are shown below:

- The Facility Restoration Program
- Blending
- N-Reactor Conversion
- PUREX Reactivation
- L-Reactor Upgrade
- High Productivity Cores
- U-236
- New Production Reactor
- Special Isotope Separation (SIS)
- PUREX Modification

The near-term programs have served to expand the productivity of present facilities or revive dormant ones. The longer term programs call for building a new production reactor as well as using new technologies to process material more efficiently. The total cost of these initiatives is well over $2 billion, plus $3 to $6 billion more if a new reactor is built.

Facility Restoration

The *Facility Restoration* program was begun in FY 1981 as a general multiphase effort to improve and restore operations throughout the materials production complex. The seven-year program is estimated to cost $462 million (FY 1985)[180] by completion. It will have made equipment replacements and system improvements at the production sites, Savannah River and Hanford, and at the feed plants, Fernald, Ashtabula, and Y-12.[181] Idaho National Engineering Laboratory, although excluded from this initiative, has its own restoration program to upgrade and expand the ICPP for receiving increased quantities of spent naval reactor fuel, separating the uranium for recycle, and storing the waste.

Blending

At production sites, several initiatives have contributed directly to increasing the output of plutonium for weapons. Prior to FY 1981, the Savannah River reactors produced weapon-grade plutonium. The *Blending* program initiative, started in FY 1981, converted the reactors to the production of supergrade (3 percent Pu-240) plutonium. By mixing supergrade with fuel-grade plutonium from Hanford, about 50 percent more weapon-grade plutonium is produced than with the reactors alone.[182]

The first supergrade production occurred in April 1981.[183] By FY 1983 the conversion was complete in two reactors (P, K), and the third (C) was producing tritium. Accelerated reactor operations for supergrade production required halving the target irradiation time and doubling the fuel throughput. This increased target fabrication activities at Fernald, Ashtabula, and Savannah River and expanded the volume of irradiated targets processed at Savannah River.

N-Reactor Conversion and PUREX Reactivation

At Hanford, two initiatives—*N-Reactor Conversion* and *PUREX Reactivation*—brought additional plutonium into the weapons program relatively inexpensively and quickly. First conversion of the N-Reactor from the production of fuel-grade plutonium to the production of weapon-grade plutonium began in early 1982 and was completed by October. The conversion increased weapon-grade plutonium production by some 600 kg per year. Fuel requirements jumped to more than twice those for fuel-grade production. The FY 1983 budget included $34.4 million to support increased fabrication requirements at the feed plants, Fernald, Ashtabula, and Hanford. In addition, most of the fuel charge-discharge and handling equipment at the N-Reactor had to be overhauled and modified. The N-Reactor plutonium could not be recovered, however, without an operating reprocessing plant. The PUREX reactivation program was thus funded in the FY 1981 budget. In November 1983 it began operations five months ahead of schedule, creating its first product in February 1984.[184] It was needed to process newly irradiated N-Reactor fuel and to recover fuel-grade plutonium (about 4 MT) from spent fuel in storage since 1972. The latter was needed for blending. Reactivating the plant cost $195 million. Annual operating costs are $71 million with another $21 million for waste management.[185] Other options have been suggested to increase N-Reactor production further. One was to increase power some 10 to 15 percent.[186] The other suggestions was producing plutonium with 5 percent Pu-240 for blending[187] instead of 6 percent. Congress has denied funding, stating that DOE "has proposed several new and expensive initiatives that appear to provide only marginal supply contributions."[188]

---

[177] HASC, FY 1984 DOE, p. 19.

[178] HAC, FY 1982 EWDA, Part 5, p. 226; House Report 98-1080, DOE Authorization Conference Report, 26 September 1984, pp. 347-49.

[179] HASC, FY 1982 DOE, p. 121; HASC, FY 1984 DOE, p. 133; Nevertheless, as DOE officials told Congress in early 1985, "We have been barely staying above the demand curve." HASC, FY 1986 DOE, p. 18.

[180] HASC, FY 1985 DOE, p. 144.

[181] HAC, FY 1982 EWDA, Part 5, p. 238; HAC, FY 1983 EWDA, Part 4, p. 262; HASC, FY 1983 DOE, p. 377; HASC, FY 1983 DOE, p. 351; HAC, FY 1984 EWDA, Part 6, p. 532; HAC, FY 1985 EWDA, Part 6, p. 865.

[182] Blending (see Figure 3.5) combines two parts of supergrade (3 percent Pu-240) plutonium with one part of fuel-grade (12 percent Pu-240) plutonium to obtain three parts of weapon-grade (6 percent Pu-240) plutonium.

[183] HASC, FY 1983 DOE, p. 278.

[184] HASC, FY 1985 DOE, p. 144. The PUREX fuel processing plant, which had operated from 1956 to 1972, was on standby.

[185] HASC, FY 1985 DOE, p. 144.

[186] HASC, FY 1983 DOE, p. 243.

[187] *Ibid.*, p. 238.

[188] Senate Report No. 97-673, EWDA, 1983, 6 December 1982, p. 93.

L-Reactor Restart

The L-Reactor Restart was another early production initiative proposed by DOE. It was to add a fourth operating reactor at Savannah River, thereby increasing production capacity by one third. The L-Reactor was placed on standby status in February 1968, during a period of decreased demand for nuclear materials. Although the initiative was proposed in late 1980 and funded soon after, the L-Reactor startup was delayed to meet state and federal environmental regulations. This occurred despite a Presidential directive to restart the reactor "as soon as possible, but no later than October 1983."[189] The reactor was restarted on 31 October 1985 and began producing supergrade plutonium for blending.[190] The total cost of upgrading the L-Reactor is estimated at $190 million.[191]

High Productivity Cores and U-236 Recovery

At Savannah River, two further initiatives, both leading to increased reactor productivity, are High Productivity Cores and U-236 Recovery program. The first involves reactor core design changes that would increase plutonium productivity. A proposal, first advanced in 1981, was to increase productivity by about 25 percent by replacing the Mark 16/31 cores used in Savannah River reactors with a uniform core of slightly enriched (1.1 percent U-235) Mark 15 fuel assemblies.[192] The replacement was considered as early as 1972.[193] A demonstration performed in the K-Reactor in August and September of 1983 verified design and operability.[194] But the Mark 15 program has proved controversial. Congress cut funding the past several years due to the cost of enrichment. In FY 1985, Congress cut $90.5 million, all that had been earmarked for enrichment, out of the $113.5 million budget.[195] DOE placed the enrichment costs at $300 million over the next two to three years.[196] Thus far, from FY 1983-85, $45.7 million has been authorized exclusive of enrichment. In the face of continual Congressional budget cuts DOE is assessing an alternative, the Mark 22S/25 core. This core consists of Mark 25 highly enriched uranium drivers and Mark 22S natural uranium targets. It would provide about half the productivity increase of the Mark 15 at about 40 percent of the cost.[197] The high productivity cores will be tested in 1986.

Table 3.27

Typical Isotopic Content of SRP Recycle Uranium

Isotope	Without PSP (percent)	With PSP (percent)
U-234	1.6	1.2
U-235	49.0	68.7
U-236	35.0	25.8
U-238	14.4	4.3
	100.0	100.0

Source: J.S. Allender and A.E. Ofalt, DPST-83-698, Savannah River Laboratory, Technical Division, 21 October 1983, p. 10.

The goal of the U-236 Recovery program at Savannah River is to "purify" the recycled HEU that is fabricated there into driver fuel for the production reactors. Since 1983 Savannah River Laboratory (under contract with TRW, Inc.) has been developing the Plasma Separation Process (PSP). PSP would recover the isotopes U-236 and, to a lesser extent, U-234 and U-238. All three build up during continued fuel recycle and irradiaton.[198] The concentration of U-236 may be as high as 35 percent. Left in, these non-fissile isotopes absorb neutrons and result in significant production loss during reactor operation. Removed, reactor efficiency increases and the need for additional HEU decreases.

Typical isotopic concentrations in SRP recycle uranium, with and without purification, by PSP are shown in Table 3.27. The PSP facility planned by DOE will process approximately 4.2 MT of uranium metal feed into 2.8 MT of product and 1.4 MT of tails.[199] DOE estimates that by using PSP some 11.7 MT to 13.1 MT of U-235 can be recovered from the "half-billion dollar" stockpile of enriched uranium at the Savannah River Plant.[200] In FY 1984, DOE spent about $20.5 million on the PSP effort. In FY 1985, $10.7 million will be used to procure PSP equipment from TRW, Inc.[201] A single module PSP plant may start operation at Savannah River in FY 1987 and reach full production the following year. The total cost of the PSP plant is an estimated $90 million (FY 1985).

---

[189] November 1982 approval directive to the FY 1983-1988 NWSM as quoted in affidavit of Herman E. Roser, Assistant Secretary for Defense Programs, DOE, 19 May 1983, in NRDC *et al.* v. William A. Vaughan, *et al.*, C.A. No. 82-3173 (D.D.C). Congress directed the DOE to prepare an EIS thus delaying the restart of the L-Reactor. On 15 July 1983, the U.S. District Court also directed DOE to prepare and publish an EIS as soon as possible. NRDC *et al.* v. William A. Vaughn, *et al.*, 15 July 1983.

[190] HAC, FY 1984 EWDA, Part 4, p. 303; DOE, FEIS L-Reactor, Vol. 1, p. 1-6.

[191] HASC, FY 1985 DOE, p. 333.

[192] This would be the heaviest reactor core loading in Savannah River history; DOE, Safety Analysis of Savannah River Production Reactor Operations, Savannah River Laboratory, DPST-100-1, Rev. 12/81, p. 4-12. The Mark 15 uniform lattice design would be the most efficient core that can be accommodated at SRP; DOE, FEIS L-Reactor, Vol. 1, p. 1-8.

[193] Smith, Safety Analysis, p. V-23.

[194] DOE, FEIS L-Reactor, Vol. 1, pp. 2-7, 1-8.

[195] From the enrichment costs one can estimate the uranium fuel requirements for this program. $50 million at $93 per SWU (FY 1984) would have supplied 0.538 million SWU for about 1000 MTU (1.1 percent U-235); $90.5 million at $96 per SWU (FY 1985) would have given 0.943 million SWU or some 1750 MTU (1.1 percent U-235), all at 0.2 percent tails.

[196] HASC, FY 1985 DOE, p. 145.

[197] HAC, FY 1984 EWDA, Part 6, p. 851. HASC, FY 1985 DOE, p. 145.

[198] PSP was a TRW-funded uranium enrichment program prior to FY 1977, when ERDA awarded TRW a contract for the performance of experimental and analytical studies toward development of source, resonator, and collector subsystems that would produce samples of enriched uranium. Extensive facilities were built to support DOE-sponsored work at TRW. By the end of FY 1983 total government expenditures were about $89 million. TRW invested some $10.3 million of corporate funds on PSP development through mid-1983.

[199] L.W. Grey, "Closing the High-Enriched Uranium Fuel Cycle at SRP," memorandum to H.D. Harmon, Savannah River Laboratory, Technical Division, DPST-83-334, 4 August 1983, revised: 16 January 1984.

[200] According to DOE cost-benefit analyses, "Based on a $34.20/g value of U-235 in uranium enriched to around 90%, the stockpile would have a disposal value of $400 to $450 million by FY 2000." Memorandum from J.S. Allender, *et al.*, to M.R. Buckner, *et al.*, Savannah River Laboratory, 3 June 1983. According to recent testimony, once in operation, the U-236 will result in annual net savings of $37.5 million per year, equivalent to about 1 MT of 90 percent enriched uranium per year.

New Production Reactor

Construction of the last U.S. production reactor was finished in 1963. Since 1980 several government studies have looked at possible designs and locations for a new tritium and plutonium production reactor (NPR).[202] Once authorized by Congress, the NPR would require about ten years to construct and would cost an estimated $3 billion to $6 billion, depending on the design.[203] DOE plans were to submit recommendations to the President on a reactor concept and site.[204] If approved, the reactor would be operational by the mid- to late-1990s.[205]

DOE has given three reasons justifying an NPR:

- "to ensure the availability of tritium to meet long term national security requirements,"[206] because of an "increasing probability over time" that the Savannah River reactors "would become unavailable,"[207]to have an alternate site to Savannah River for the production of tritium and for plutonium once the N-Reactor is shut down, and
- to bolster deterrence, since "without a reactor in our planning, we are going to send a message to the world that we may not have a reliable stockpile."[208]

Most of the reactor technologies conceived or developed over the past forty years have, at some time, been considered for the NPR. Three types of reactors at three possible sites were being examined: a heavy water reactor (HWR) at Savannah River, a HWR or a high temperature gas reactor (HTGR) at Idaho National Engineering Laboratory, and a HTGR or a pressurized-water reactor (PWR) at Hanford.[209]

One NPR study known as the Glennon Report was issued in November 1982 by DOE's New Production Reactor Concept and Site Selection Advisory Panel. The Glennon Report ranked as its first choice for the NPR the zero electric power heavy water reactor (ZEPHWR) at Savannah River. It placed Idaho last, after Hanford, in its choice of sites.[210] Subsequently, a study on nuclear materials needs written for the Office of Science and Technology Policy emphasized the desirability of an alternate site to Savannah River for tritium and plutonium production. An earlier study on materials needs by UNC Nuclear Industries had narrowed the production alternatives to five reactor concepts.[211]

Congress, following the lead of the House Armed Services Committee, has been reluctant to support a new production reactor. In 1983 the Committee rejected the need for the NPR arguing that up to four Savannah River reactors would be available in the early 1990s due to a slack in demand for plutonium production.[212] A year later the committee noted, "It would appear that a political assessment of state and local attitudes toward such a project should be made prior to selection of a site for other reasons."[213]

Originally, studies for the NPR concentrated on large reactors, comparable in power to the largest commercial reactors in the United States. By 1985 DOE had broadened its studies to consider smaller reactors of the same type. In 1986, DOE decided to defer indefinitely the NPR, pending the completion in mid-1987 of "life cycle" studies of the existing DOE production reactors.

Special Isotope Separation (SIS)

Using lasers to separate isotopes was suggested in the United States in 1971 by the Los Alamos National Laboratory.[214] Since then, the development of laser isotope separation (LIS) technology has expanded to include major government sponsored LIS efforts for uranium enrichment and plutonium purification.

Research to develop a technology for enriching plutonium in the "desirable" isotope plutonium-239 was launched in secret by the AEC in 1975 at LLNL and LANL.[215] During the initial years, the program operated at a low level of effort.[216] In FY 1980, the plutonium SIS program was formally initiated.[217] In addition to the two plutonium LIS processes, it included, at a much lower level of support, the (non-laser) PSP developed by TRW and LANL.[218] This PSP is currently being utilized in the U-236 recovery program.[219] These same processes were under development for enriching uranium in U-235.[220]

---

[201] HAC, FY 1985 EWDA, Part 4, p. 440. Installation is to be in Building 305M at Savannah River.

[202] The recommendation for a new production reactor, or reactors, was contained in the Starbird Report in mid-1980, p. 16. The concept was first known as the RPR or replacement production reactor.

[203] HAC, FY 1985 EWDA, Part 6, p. 858; higher estimates of $4 to $8 billion are made in House Report 98-124, Part 1, 13 May 1983, p. 19; and $12 to $16 billion with requirements for earthquake, hurricane, and tornado standards; Ibid.

[204] HASC, FY 1985 DOE, pp. 150-51; SASC, FY 1986 DOE, p. 62.

[205] HAC, FY 1985 EWDA, Part 4, p. 433. In early 1982, the target date was 1992; HASC, FY 1983 DOE, p. 235; *Inside NRC*, 2 November 1981, p. 4.

[206] HAC, FY 1985 EWDA, Part 4, p. 433.

[207] *Ibid.*; See also HAC, FY 1984 EWDA, Part 6, p. 533. The President's Private Sector Survey on Cost Control noted that there are "no identifiable reasons" why the Savannah River reactors "should not remain operable well past the turn of the century"; Draft Report, 15 April 1983, p. 23. With regard to when the NPR would be needed, studies are underway to reduce the uncertainty in the useful lifetime of the Savannah River and N-Reactors; without costly renovations the N-Reactor is expected to reach the end of its useful life in the mid-1990s; HAC, FY 1985 EWDA, Part 6, p. 858.

[208] HASC, FY 1985 DOE, p. 150. However, arguments in favor of NPR operaton by the early 1990s were necessarily blunted by cancellation of the SENTRY anti-ballistic missile (ABM) and other enhanced radiation warheads in the early 1980s, thus reducing projected nuclear materials requirements.

[209] The Secretary of Energy's preferred choice in 1983 was the HWR at Idaho. Memorandum from Donald Paul Hodel, Secretary of Energy, to Herman Roser, Assistant Secretary for Defense Programs, 9 August 1983. As a result of Congressional pressure, Savannah River was restored to consideration and environmental impact statements are including all three candidate sites. An HTGR of the required size has never been constructed in the United States, and it as well as the PWR and their fuel cycles need further development; HAC, FY 1985 EWDA, Part 6, p. 859.

[210] Report of the New Production Reactor Concept and Site Selection Advisory Panel (unclassified version), T. Keith Glennon, Chairman, DOE Q-DO-82-97, 15 November 1982. The panel evaluated the adequacy of future supplies of strategic nuclear materials and reviewed seven reactor concepts and four sites. The second choice, if byproduct steam was required, was the vertical-pressure-tube low temperature heavy water reactor at Savannah River or the Replacement N-Reactor at Hanford. The latter was favored if an alternate site for tritium production was essential. Other sites were INEL, judged less suitable because of possible contamination of the aquifer and lack of barge access and local construction labor and "without many of the facilities and technologies required for a strategic materials production site;" ibid., pp. 3, 5-9. Other concepts included the light water reactor using highly enriched uranium fuel, the liquid metal fast breeder reactor, the HTGR, and the partially completed Washington Public Power Supply System pressurized water reactor, WNP-4, located on the Hanford Reservation; ibid., p. 3. Although opposed by the panel on economic grounds, the production of byproduct steam was still one of the DOE ground rules; *Ibid.*, p. 25; HASC, FY 1983 DOE, April 1982, p. 239; S.V. Jackson, Los Alamos National Laboratory, LA 8898-MC, June 1981.

[211] United Engineers and Constructors—United Nuclear Industries, APR Feasibility Study, Draft Report, UE&C-UNC/DOE-810225, circa 1980.

[212] House Report 98-124, Part 1, 13 May 1983, p. 19.

[213] House Report 98-724, 26 April 1984, p. 28.

[214] HASC, FY 1980 DOE, p. 150.

[215] HASC, FY 1982 DOE, pp. 162, 174.

The purpose and scope of the plutonium SIS program were first publicly revealed in 1981.[221]

At least a half a dozen weapons-related applications of LIS processes for plutonium have been considered. One application is enriching reactor-grade plutonium recovered from commercial power reactor spent fuel[222] or fuel-grade plutonium from the N-Reactor for weapons use.[223] Plutonium from civil reactors is not directly useful to the nuclear weapons program because of the high Pu-240 and Pu-241 content. Another is separating out the Pu-240 and Pu-241 from the existing inventory of weapon-grade plutonium. This would reduce radiation exposure to plant and military personnel.[224] A third application would provide a source of non-fissile isotopes Pu-240 and Pu-242 for research. Plans exist to build an SIS production plant.[225]

In 1982 Congress banned the use of plutonium from commercial spent fuel in weapons.[226] This legal prohibition eliminated one of the principal justifications for the SIS program and the construction of a plutonium LIS plant. Nevertheless, the SIS program continues to receive a high level of funding from Congress at the behest of the authorizing and appropriating committees and despite uncertain support from the Administration. DOE continues to emphasize the need for this technology to enrich up to 11 MT of fuel-grade plutonium,[227] as well as an eventual "clean-up" of the existing weapon-grade stockpile.[228]

The potential SIS feed includes the plutonium currently being used in continuing civil R&D activities for the breeder program. The 6.3 MT of fuel-grade plutonium in the fuel of the two breeder program facilities, the Fast Flux Test Facility (FFTF) and the Zero Power Plutonium Reactor (ZPPR), will become available for other uses in the early 1990s.[229] The FFTF and ZPPR facilities are now the depository of most of the fuel-grade plutonium from civil reactors received by the United States in barter from the United Kingdom between 1964 and 1969 under the Mutual Defense Agreement of 1958. Should the United States continue its policy of not using the bartered plutonium for weapons, the SIS plant would have as its primary mission the clean-up of only about 7 MT of fuel-grade plutonium.

FY 1981 through FY 1985 funding for the SIS program totaled $295 million. Congress has shown more enthusiasm for the program than the Reagan Administration. The pattern has been for the Office of Management and Budget (OMB) to cut back on the SIS funding sought by DOE, and for Congress to restore it partially. For example, the FY 1985 DOE request for the SIS program was $100 million for operating expenses and capital equipment; OMB cut SIS funding to $39 million and Congress restored it to $69 million.

Most funding for SIS over the years has gone to support the LLNL AVLIS process, which has always been recognized as being in the lead for plutonium LIS development. In 1982, the Livermore group conducted a successful laser isotope separation experiment, and in December of that year the DOE-sponsored Peer Review of the SIS program (Kintner Report) concluded that the AVLIS process appeared to be significantly far more advanced than the MLIS process for plutonium enrichment. Earlier in the year, at the end of April 1982, AVLIS won out against MLIS in the competition for uranium enrichment in the AIS program.[230]

In August 1983, the Secretary of Energy announced his selection of DOE's Hanford Reservation in Richland, Washington, as the site of an SIS production plant using the AVLIS process for plutonium enrichment. The plans call for a facility costing some $600 million to be in full production at Hanford by 1992, preceded by an AVLIS prototype operating in 1987 to 1988 at LLNL.[231] From published information, the design capacity of the plant is estimated at some 3 MT or more of plutonium output annually.[232] To recover fuel-grade plutonium to be used as SIS feed, DOE is also planning a *Process Facility Modification* at the Hanford PUREX plant that will enable processing of irradiated FFTF fuel (16 percent Pu-240).

Several issues continue to loom over the SIS issue: the need in the weapons program for an SIS plant, the technical risk involved in an accelerated SIS program, the relative costs of SIS and alternatives for acquiring additional quantities of weapon-grade plutonium, and the merits of the Los Alamos molecular laser (MLIS) process for plutonium enrichment.

---

[216] *Ibid.*, p. 182.

[217] HASC 96-39, March-June 1980, p. 580.

[218] PSP for plutonium experienced technical problems and was withdrawn by TRW from the SIS program as of FY 1983; HAC, FY 1985 EWDA, Part 6, p. 850. PSP technology is being developed to recover uranium-236 from the recycled HEU fuel of the Savannah River production reactors.

[219] HAC, FY 1986 EWDA, Part 6, p. 715.

[220] See Chapter Five, Uranium Enrichment, for a description of the AVLIS, MLIS, and PSP processes for uranium.

[221] HASC, FY 1982 DOE, pp. 159-66, 174-76, 236.

[222] HASC, FY 1982 DOE, p. 160.

[223] HASC, FY 1983 DOE, pp. 157, 175.

[224] *Ibid.*, p. 160; testimony of F.C. Gilbert to the Subcommittee on Oversight and Investigations of the House Committee on Interior and Insular Affairs, 1 October 1981.

[225] HASC, FY 1982 DOE, pp. 140, 161, 175.

[226] The Hart-Simpson-Mitchell amendment to the NRC Authorization Act for FY 1982-83, Public Law 97-415, was passed by the Senate on 30 March 1982 and signed into law on 4 January 1983.

[227] HAC, FY 1984 EWDA, Part 6, pp. 364-65.

[228] House Science and Technology Subcommittee on Energy Research and Production [No. 121], Vol. VI, March-May 1982, p. 484.

[229] Letter from Donald Paul Hodel, Secretary of Energy, to Richard L. Ottinger, 5 March 1984, Enclosure.

[230] The House Armed Services Committee, in its May 1983 report, called for a halt to MLIS support and the choice of the AVLIS process for full-scale demonstration; HASC Report 98-124, pp. 17-18.

[231] Nucleonics Week (11 August 1983): 4.

[232] According to testimony of F. Charles Gilbert, Deputy Assistant Secretary for Nuclear Materials, DOE, the maximum rate at which plutonium can be made available for weapons through blending supergrade and fuel-grade plutonium is less than the SIS alternative. HAC, FY 1983 EWDA, Part 6, p. 349.

The Administration's FY 1985 DOE budget justification referred to an "uncertainty as to whether a production facility is required." OMB, in the document, attacked any implication that SIS would provide cheap plutonium for weapons:

> The SIS process has the highest cost (in total dollars and in dollars per gram of additional plutonium) of the various methods of increasing productivity. The SIS process also requires the most lead time and is the most technologically uncertain.[233]

The administration's SIS schedule, proposed in early 1984, called for continued research and development on the plutonium AVLIS process at Livermore—on both separator hardware and laser technology. This would lead to an AVLIS process demonstration at Livermore in FY 1987[234] and would leave open the option to begin construction of an SIS plant at Hanford for operation in the early 1990s.[235] Design of systems to support a possible SIS plant continues at Hanford.[236]

In early 1984, the White House Office of Science and Technology Policy (OSTP), supporting a delay in commitment to an SIS production plant, requested yet another SIS technology review and process selection. The OSTP study reconsidered both AVLIS and MLIS technologies for the plutonium enrichment plant.[237] As a result of the OSTP study, completed in late 1984, plans for development of the AVLIS prototype were not altered, but a decision on the final choice between AVLIS and MLIS was delayed until completion of yet another review. With the AVLIS process, LLNL demonstrated the removal of a single "unwanted" plutonium isotope on a laboratory scale sometime in FY 1984.[238] By early 1985 they tested a module of full-scale plant size equipment. Also in 1985, Los Alamos, using the MLIS technology, demonstrated the highest separation factor of any process and was nearing completion of an enrichment facility (SIS-III) intended to meet the Laboratory's needs for special isotopes of plutonium (Pu-240 and Pu-242) for research purposes.[239]

PUREX Process Facility Modification

The Process Facility Modification (PFM) is important for DOE's plans to operate an SIS plant at Hanford in the early 1990s. The program will modify the PUREX plant to handle high burnup oxide fuels in stainless steel or zircalloy cladding. The necessary modifications will allow the PUREX facility to receive and store the high burnup fuel, chop the stainless steel cladding into short lengths, and dissolve the contained oxide fuel material (these two operations are known as shear/leach), and dilute the dissolved material for further chemical processing.[240]

The immediate objective of PFM is to recover fuel-grade plutonium from irradiated FFTF fuel and other DOE-owned research fuels. PFM will also give PUREX the capability to process other high burnup fuels. DOE claims it has no plans to process commercial light water reactor fuel in the PFM project.[241] However, in connection with the design for handling FFTF fuel, "there may be a limited capacity to handle commercial fuel, but it would require major capital additions . . . to handle any substantial quantity."[242] The design capacity calls for a maximum of 10 MT of FFTF fuel per year containing about 2 MT of plutonium (15 percent Pu-240).[243] The expanded plant would possibly have a capacity of up to 5 MT per day of commercial type fuel.

Funding for the PFM program began in FY 1983. Construction of facility modifications is estimated at $155 million, and is expected to begin in FY 1986 and end in FY 1990.[244]

---

[233] HAC, FY 1985 EWDA, Part 4, p. 431.

[234] Ibid.

[235] FY 1986 EWDA, Part 6, pp. 762-63.

[236] Ibid.

[237] FY 1986 EWDA, Part 6, pp. 583, 577-78, 848-49, 913; House Report 98-72, 20 April 1984, pp. 26-27.

[238] FY 1986 EWDA, Part 6, p. 714. In the AVLIS SIS separator the "unwanted" plutonium isotopes are swept out of a beam of plutonium metal vapor leaving plutonium vapor enriched in Pu-239; Ibid., p. 676.

[239] SASC, FY 1986 DOE, p. 152.

[240] M.M. Beary, et al., "Functional Design Criteria, Process Facility Modification," Rockwell Hanford Operations, SD-414-FDC-001, January 1983, p. 1-1.

[241] Letter from Hodel to Ottinger, 5 March 1984, op. cit., Enclosure 1.

[242] Letter from Donald Paul Hodel to Richard Ottinger, 30 August 1983, enclosure. The Hart Simpson Mitchell amendment, P.L. 97-415, prohibits use of special nuclear materials produced in NRC licensed facilities for nuclear explosives.

[243] Letter from Donald Paul Hodel to Richard Ottinger, 5 March 1984, Enclosure 1.

[244] HASC, FY 1985 DOE, p. 146.

United States General Accounting Office

GAO

Testimony

For Release
on Delivery
Expected at
9:30 a.m. EST
Tuesday
June 16, 1987

Key Elements of Effective Independent Oversight of DOE's Nuclear Facilities

Statement of
J. Dexter Peach, Assistant Comptroller General
Resources, Community, and Economic Development
Division

Before the
Committee on Governmental Affairs
United States Senate

Mr. Chairman and members of the Committee:

We are pleased to be here today to provide our comments on the proposed Nuclear Protections and Safety Act of 1987 (S. 1085). Our testimony today will focus on Title I which establishes a Nuclear Safety Board to oversee DOE's nuclear facilities.

As you know, Mr. Chairman, GAO has a long history of supporting the need for independent oversight of various aspects of DOE's nuclear facilities. As I pointed out at this Committee's March 12 hearing, many of DOE's nuclear facilities are old, some are already operating beyond their expected life, and there are many unresolved concerns about the operational safety of and environmental problems at many of these facilities. The scope and importance of those concerns, coupled with the age of the facilities, caused us not only to reiterate our positions on the need for independent oversight, but also to recommend that DOE develop a strategy for its defense complex. This strategy would define the universe of problems DOE faces and present an action plan with timeframes and cost estimates for upgrading or building new facilities. Development of this strategy combined with effective oversight should help to assure the Congress and the public that these facilities, whether refurbished or new, are safe.

We believe that for any oversight approach to be effective in ensuring safety, it should have five key elements:

-- independence

-- technical expertise

-- ability to perform reviews of DOE facilities as needed

- clear authority to require DOE to address the organization's findings and recommendations
- a system to provide public access to the organization's findings and recommendations

Mr. Chairman, the proposed legislation creating a Nuclear Safety Board addresses each of these elements and therefore has the potential to be an effective mechanism for oversight of DOE's nuclear facilities. We also believe that these elements would serve as useful criteria in assessing any proposal that the Congress may consider.

Let me briefly describe our past positions on independent oversight, the types of problems we have identified in the safety area, and then describe the five key elements and how the Board meets those elements. In addition, we have some observations which we believe will assist the Committee in fine-tuning the bill.

GAO'S PAST WORK

We have a long history of recommending oversight of DOE operations. In a 1981 report, we pointed out that one of the basic, underlying causes of shortcomings in DOE's safety programs was its structure within DOE.[1] In that report, we argued for a separate office within DOE specifically set up to oversee safety matters within the department, and we stated that the office should report to the Under Secretary of Energy. Although DOE originally disagreed with our recommendation, in September 1985, it established the Office of the Assistant Secretary for Environment, Safety, and Health, that reports to the Under Secretary. We believe that DOE's action, in effect, adopted our 1981 recommendation.

---

[1] Better Oversight Needed for Safety and Health Activities at DOE's Nuclear Facilities (EMD-81-108, Aug. 4, 1981).

Also in the 1981 report and again in a 1986 report, we highlighted the need for outside, independent reviews of safety analysis reports--important documents which are designed to show that DOE facilities are safely designed, constructed, and operated. In response to our 1986 report, DOE believed that its own Office of Assistant Secretary for Environment, Safety, and Health provides sufficient independent review.[2] At that time they stated that

> ". . . an additional level of oversight, over and above that already existing under the guidance of the Assistant Secretary for Environment, Safety, and Health, would not provide any additional assurances of the safe operations of DOE facilities. . ."

Our work on safety matters at DOE facilities over the past few years has not changed our position on the need for this oversight. On the contrary, our work has raised serious questions about both the safety of individual facilities and DOE operations as a whole. For example, during this Committee's March hearings, we disclosed that at DOE's Savannah River Plant, the reactors were potentially unable to cool the core in the event of a serious accident. Because of this safety concern, DOE's contractor at Savannah River reduced the operating power of the reactors in the fall of 1986. After the hearings, DOE further reduced the operating power because the National Academy of Sciences, which at DOE's request is reviewing its reactors, felt the initial reduction was not sufficient to assure safety.

---

[2] Safety Analysis Reviews for DOE's Defense Facilities Can Be Improved (GAO/RCED-86-175, June 16, 1986.)

At that same hearing, we again highlighted the need for independent oversight as well as for DOE to develop a strategy for its defense complex. In addition, we recommended to the Secretary of Energy that DOE develop an overall strategic plan that sets forth the projected facility requirements for continued nuclear weapons production; a comprehensive picture of the environmental, safety, and health issues facing DOE; and solutions to resolve them. DOE officials have informally told us they agree with our recommendation.

We now understand that Secretary Herrington has endorsed the concept of outside independent oversight and that the department is now assessing various alternatives and will soon decide on the preferred approach.

KEY ELEMENTS OF EFFECTIVE INDEPENDENT OVERSIGHT

As I indicated at the outset of my statement there are five elements that should be incorporated into any approach for independent oversight. Let me briefly discuss each of these elements and why they are important.

Independence means the organization must be structurally distinct and separate from DOE. This is important so that the organization is visibly removed from DOE's influence in funding, staffing, and setting of safety agendas. Only in this way can conflicts between DOE's programmatic and safety goals be prevented. In the past, we have pointed out that such conflicts can and do occur. For example, during the 1970s, DOE considered closing the Fernald plant in Ohio. As a result, it did not make capital improvements and equipment became obsolete. In the early 1980s, DOE's production goals increased, putting a strain on the plant's resources. According to DOE's own documents, Fernald's management emphasized production over worker safety and health concerns.

The second element is technical capability. Any oversight organization must have the technical knowledge and capability to fully understand how DOE facilities are designed and operated and what the safety ramifications are of their operation. This is particularly important in overseeing the unique facilities and operations that DOE manages. Such expertise is necessary so that sound safety assessments are made and so that the organization is not too dependent on DOE's information for developing its own findings and recommendations. This technical expertise must exist not only at the top level where decisions are made, but at the staff level where detailed analytic work is performed. Sufficient staffing is also important so that the technical staff is not limited to cursory reviews.

The organization should have the ability to perform reviews of DOE facilities as needed. These reviews could range from an annual review to continual day-to-day oversight depending on the nature of the issues being addressed. These reviews are important to maintain a working knowledge of DOE safety issues and to assess DOE's response to their recommendations. The organization's staff will also develop a better understanding of how DOE operates on a continuing basis rather than on a one-time or sporadic basis. Therefore, the organization could immediately respond to safety concerns. An important factor in the organization's ability to perform reviews when needed is clear access to DOE facilities and records. Without this access, timely and complete assessments may not be possible.

Next, the organization should have the clear authority to require DOE to address the organization's findings and recommendations. Such accountability is important so that DOE will seriously consider and act on these findings and recommendations. Without such influence the organization could easily become a DOE "consultant-type" organization, which could be a drawback. For example, DOE established the Roddis panel--an outside group of nuclear experts--to review the safety of its N-reactor in Washington State. This panel raised a number of fundamental issues regarding various safety aspects of the N-reactor and made recommendations to improve its operation. DOE was not required to act on the recommendations, but several months after receiving the panel's reports, DOE temporarily shut down the reactor ahead of schedule to upgrade safety systems. This upgrade included implementing some of the panel's recommendations, however, there is now concern that while DOE has begun to implement their recommendations, all will not be complete prior to the planned restart of the reactor.

Finally, the findings and recommendations of the organization, if they are not classified, should be publicly available. This is important so that the Congress and the public can have a better understanding of the problems DOE faces and the risk in operating DOE nuclear facilities. Public disclosure of safety issues as they are identified will avoid piece-meal disclosures, as have happened in the past, and will also keep the Congress and the public fully informed about the condition of DOE's facilities.

In summary, we believe the five elements are important to the establishment of an independent safety oversight organization. If these elements are present, the organization becomes more credible and thus can help to ensure that DOE operations are safe.

NUCLEAR SAFETY BOARD MEETS THE KEY ELEMENTS OF EFFECTIVE INDEPENDENT OVERSIGHT

We believe that congressional debate concerning the proper vehicle for outside independent oversight should consider the five key elements we have just laid out. Accordingly, we have assessed the provisions of S. 1085 within the context of these elements and concluded that all five elements were clearly met. In that regard, let me briefly summarize why we believe the Safety Board meets each of these elements.

Independence

The Nuclear Safety Board is a new organization established by this legislation and is organizationally separate and distinct from

DOE. In this regard, the Board will be independent of DOE in obtaining funding and resources, and deciding on its own review agenda. Further, it will also have no operational responsibilities for DOE nuclear facilities. The Board members are appointed by the President, with the advice and consent of the Senate, and a Board member can only be removed by the President. Since there is no link or line of authority between DOE and the Board, it separates those making production decisions from those reviewing the safety aspects of the facilities. Therefore, the Board can take strong positions on the results of its reviews without considering operational needs. DOE would then be responsible for factoring in these needs in responding to any safety concerns raised by the Board.

Technical capability

The Nuclear Safety Board, as proposed in the legislation, is structured to obtain or acquire the necessary expertise to perform the functions established for the Board. For example, the proposed legislation states that the Board members must be respected experts in the field of nuclear safety. In addition, they must have "a demonstrated competence and knowledge relevant to the independent investigative and prescriptive functions of the Board." Also, the Board is authorized to hire a technical staff and to employ consultants if needed. Further, the proposed legislation would authorize the Advisory Committee on Reactor Safeguards, a technical advisory group to the Nuclear Regulatory Commission, to expand its membership by up to five members and corresponding staff to assist the proposed Nuclear Safety Board in assessing DOE activities.

Ability to Perform Reviews of DOE Facilities as Needed

The proposed legislation requires the Board to issue an annual report which addresses for each DOE nuclear facility (1) the implementation of health and safety standards and (2) the quality and implementation of all DOE orders governing these facilities. The proposed legislation also provides sufficient flexibility for the Board to review any aspect of DOE's nuclear facilities at any time during the year. Over the years, the Board is intended to be a fixed entity which has acquired an institutional knowledge about the DOE facilities and is available to review those facilities as often as required. In order to perform these reviews as needed, the proposed legislation states that the Secretary of Energy and all contractors operating DOE nuclear facilities should fully cooperate with the Board and provide ready access to the facilities and information necessary to complete the Board's review.

Clear Authority to Require DOE to Address the Organization's Findings and Recommendations

DOE must take specific action on each of the Board's recommendations--either implementing it or notifying the Board and the Congress that the recommendation cannot be accomplished because (1) it is technically infeasible or (2) the President has exempted the facility from complying with the recommendation because it is in the "paramount interest of the United States to do so." The exemption is effective for up to 1 year, but is renewable upon issuance of a new presidential determination. Therefore, DOE is forced to seriously consider each and every recommendation raised by the Board.

System to Provide for Public Access to the Organization's Findings and Recommendations

The legislation states that the Board's recommendations shall be sent to the Congress, and if not classified, to federal, state, and local government agencies and be made available to the public. This will allow for the people most affected by the operations of the facilities to obtain information on the safety of these facilities from an independent reviewer not affiliated with DOE.

POSSIBLE CLARIFICATIONS TO THE BILL

Overall, the Safety Board, as proposed by this legislation, meets the key elements, therefore, has the potential to effectively oversee DOE's nuclear activities. We do have the following observations which we believe will assist the Committee in fine-tuning the bill.

As I pointed out earlier, the Safety Analysis Reports are intended to show that DOE facilities are safely designed, constructed, and operated. These reports are prepared by the facility contractor operator and require approval by DOE. These reports establish a basis for both the operator and DOE to determine that its facility can operate safely and to conclude that operating the facility does not pose an unacceptable risk to public health and safety. However, we have found that these reports have not always done what they set out to do--some provided little or no comparison to safety criteria, some used different approaches to analyze accidents, and some have not been approved. Given the importance of these documents, we have recommended that the reports on the facilities which involve significant nuclear hazards be reviewed by an outside group to provide independent assurance that these facilities are safely designed and operated. Therefore, while the bill is flexible in allowing for the Board to review these reports, we believe the review function should be highlighted as a specific responsibility of the Board. The Board would review the Safety Analysis Reports and make any recommendations public. DOE, in turn could accept and/or rebut the review. This function may become particularly important as DOE rebuilds its nuclear defense complex.

Another area that needs clarity is what health and safety standards the Board is to use in assessing the facilities. The bill tasks the Board with annually reviewing and evaluating the implementation of health and safety standards, as well as all applicable DOE orders at each DOE facility. In addition, a provision of the bill directs the National Academy of Sciences or some other group of experts to evaluate and interpret the differences between Nuclear Regulatory Commission regulations and DOE orders governing safety. However, there is no clear indication as to whether the Board should use the results of this analysis, establish its own standards, rely on DOE orders, or use existing NRC guidance for commercial nuclear facilities. We believe the bill should more clearly define what standards the Board should apply.

KEY ELEMENTS SHOULD BE APPLIED TO ANY OPTION CONSIDERED

Other bills which address oversight of DOE nuclear facilities are currently being debated in the Congress, and other approaches to independent oversight might be surfaced. We believe that any proposal that the Congress considers must be analyzed to determine if it meets the five key elements. It is possible that some other proposals may satisfy all of these elements. If that is the case, then other considerations such as cost and the intensity of oversight that Congress believes is needed would enter the debate.

As one example of other proposals, the Senate Energy and Natural Resources Committee has reported out S. 748, which among other things, establishes a new Inspector General for Nuclear Programs and establishes a panel to recommend a method of independent oversight to the Congress by January 1989. As I mentioned earlier, DOE is reconsidering its earlier position on independent oversight and is currently analyzing various options. Therefore, DOE and others may propose additional approaches as congressional debate continues.

In closing, Mr. Chairman, we commend you for consistently being at the forefront of this issue. We believe that S. 1085 clearly includes all five elements we believe important to establish an effective approach to independent oversight of DOE's nuclear facilities. As the Congress debates this and other proposals which exist or may be introduced, we believe that each proposal should be assessed as to whether or not they meet the five elements outlined.

That concludes my testimony for today. We would be pleased to respond to any questions you or members of the Committee may have.

United States General Accounting Office

GAO Testimony

For Release
on Delivery
Expected at
9:00 a.m. EST
Thursday
April 9, 1987

Security Clearance Reinvestigations of Employees Has Not Been Timely at the Department of Energy

Statement of
Keith O. Fultz, Associate Director
Resources, Community, and Economic
Development Division

Before the
Subcommittee on Environment, Energy, and
Natural Resources

Committee on Government Operations
House of Representatives

Mr. Chairman and Members of the Subcommittee:

We appreciate the opportunity to discuss the results of our review of the Department of Energy's (DOE) reinvestigation of employee security clearances. This review was performed at your request and the results were included in our report entitled DOE's Reinvestigation of Employees Has Not Been Timely, to you on March 10, 1987. This report addresses only one element--employee reinvestigations--of DOE's security clearance program. The results of our ongoing work on other aspects of this program, being performed at your Subcommittee's request, will be provided to you this summer.

Essentially, Mr. Chairman, our review disclosed that DOE headquarters and some field offices have not met DOE's past security clearance reinvestigation goals and, perhaps more significantly, may not be able to meet them in the future. Clearance investigations are important because they are aimed at identifying employees of questionable trustworthiness. Because DOE has not performed many reinvestigations (about 76,000 of 121,000 employees at DOE headquarters and at three field offices we reviewed are overdue for a reinvestigation) employees are being allowed to perform classified work although they may not be suitable for a security clearance. DOE's workforce had included cleared employees holding sensitive jobs in weapons production facilities who had serious drug, alcohol, or other problems that raised questions about their suitability for clearance. Furthermore, DOE may now have similar employees in its work force but such employees may not be identified until required investigations are completed. Because of the importance of the reinvestigation program, we recommended that the Secretary of Energy develop a plan to bring headquarters and field offices into compliance with DOE's directive on clearance reinvestigations.

Before discussing the details of our review, I would like to provide a brief overview of DOE's security clearance program.

BACKGROUND

Many of DOE's programs involve sensitive, national security issues; the nuclear weapons program is one of the most sensitive. To protect these programs from security breaches, DOE requires employees--its own and those of its contractors--to obtain a security clearance to establish their trustworthiness. The investigations required for initial clearances and for reinvestigations are performed for DOE by the Federal Bureau of Investigation (FBI) and the Office of Personnel Management (OPM).

DOE and other federal employees with access to DOE's facilities or records and DOE contractor employees hold about 218,000 clearances. DOE employees hold about 4 percent of the total; contractor employees, about 93 percent; and other government agencies' employees and congressional staff, the remaining 3 percent.

To ensure the continued trustworthiness of cleared employees, DOE currently requires all cleared employees to be reinvestigated at 5-year intervals.

DOE issues five levels of clearances: Q sensitive, Q nonsensitive, Top Secret, "L", and Secret. An employee with a Q-sensitive clearance has access to nuclear weapons design, manufacture, or use data; disclosure of information along these lines to a foreign, hostile source could cause exceptionally grave damage to the nation. On a lesser scale, an employee with a secret clearance has access to information on the military's plans for using nuclear weapons; disclosure of this information could result in serious damage to the nation. The level of clearance determines the scope and depth of the initial investigation and the reinvestigation; it also dictates the type of information, facilities, and material to which an employee has access. (Attachment I shows the clearance levels and the type of reinvestigation required).

Management of the clearance program is decentralized with responsibility distributed among headquarters and the eight field offices that oversee the activities of numerous contractors at 27 DOE-owned facilities. The headquarters Director of Safeguards and

Security is responsible for setting security clearance policies and directing the clearance program for headquarters employees. The Director is not responsible for staffing or funding the clearance programs at the field offices. DOE's eight field office managers are responsible for their own clearance programs.

Our review was performed at DOE headquarters and the Richland, Washington; Oak Ridge, Tennessee; and Albuquerque, New Mexico, offices which have about 121,000 clearances--about 55 percent of DOE's 218,000 clearances. At the time of our review, about 76,000 of the 121,000 employees in these offices were overdue for a reinvestigation. Clearance information on the type, level, and reinvestigation backlog for these offices is shown in attachment II.

PERIODIC REINVESTIGATION OF EMPLOYEES HAS NOT BEEN TIMELY

DOE requires that previously cleared employees be reinvestigated periodically to determine whether personal problems, such as indebtedness, alcoholism, drug abuse, or mental illness, have developed since they received an initial clearance. These reinvestigations are needed to determine whether an employee with such personal problems could be a possible candidate for certain activities, such as espionage, that would endanger national security. Failure to conduct required reinvestigations increases the potential for security risks because personal problems can go undetected for a long time without DOE evaluating whether a clearance should be revoked. We are concerned that some DOE offices have not fully implemented the periodic reinvestigation program in the past and, perhaps more significantly, may not be able to implement it in the future.

Importance of Conducting Timely Reinvestigations

Recent security leaks at various federal agencies have shown that cleared employees can change their behavior in ways that pose a significant security threat. Our review of DOE's reinvestigation program shows that some cleared DOE employees are engaged in activities that raise questions about their suitability for a clearance. For example, in 1984, Oak Ridge's review of security questionnaires completed by employees identified between 2,500 and 3,000 employees who needed a reinvestigation to determine whether problems they reported, such as drug use, were serious enough to warrant terminating their clearances. In addition, in 1986, Oak Ridge identified 250 of 12,000 employees at one facility suspected of using drugs, including 6 security guards who worked at and had access to all parts of facilities where various weapons parts were manufactured. Oak Ridge discussed the alleged drug use with the 250 employees. Subsequently, five of the security guards were suspended and other appropriate actions are underway for the other guard and remaining employees.

In some cases DOE is provided information about their employees by others, such as the local police, when an arrest is made that raise security concerns. In some instances, those concerns might have been identified earlier if DOE offices had performed required reinvestigations. For example, in our review of the 171 most recent cases (as of July 1986) at Oak Ridge and Richland where clearances were being considered for termination, we found that 22 cases were overdue reinvestigations. If those reinvestigations had been done, their problems may have come to DOE's attention earlier. These employees held sensitive jobs, such as armed security guards, and also had serious alcohol and drug use problems--including on-the-job drug use.

Pre-December 1985 Reinvestigation Policy Was Not Fully Implemented

Prior to December 1985, DOE required that only employees with the highest clearance level--about 12,000 of its 218,000 clearances--have their backgrounds reinvestigated every 5 years. Even with this relatively limited reinvestigation program, DOE offices were not able to perform the required reinvestigations. DOE clearance officials attributed their inability to meet reinvestigation requirements to such things as management inattention, inadequate budget and staff resources, insufficient support from OPM, and an increase in the workload generated by clearance questionnaire forms that DOE revised in 1983. Specifically, we found that

-- headquarters did not do periodic reinvestigations for DOE headquarters employees until 1982 and did not begin doing them for headquarters contractors until January 1987;

-- Richland had no reinvestigation program prior to 1985; and

-- Oak Ridge had developed a reinvestigation backlog by early 1984.

Albuquerque appears to have met the pre-December 1985 reinvestigation requirements.

DOE attributed the problems with the reinvestigation program at headquarters and the field offices to a variety of reasons. Headquarters security clearance officials told us the funds headquarters requested to perform required reinvestigations between 1977 and 1981 were denied by either DOE, the Office of Management and Budget, or the Congress. Although headquarters received funds and began a reinvestigation program in 1982, a February 1985 report assessing headquarters' security program prepared by DOE's Office of Security Evaluation, noted that headquarters was not conducting scheduled reinvestigations for contractors because funds and staff were inadequate. Although the report and headquarters officials acknowledged a shortage of funds, our review disclosed that between fiscal years 1984 and 1987, DOE's budget submissions to the Congress stated that it had adequate funds to meet clearance requirements.

A Richland official told us that it did not have a reinvestigation program until 1985 because of inadequate staff and funds and because DOE headquarters did not encourage Richland to conduct reinvestigations. Oak Ridge officials told us they were able to comply with its reinvestigation requirements until 1984 when a newly revised security questionnaire identified over 2,500 cases (out of about 5,000 cases received) with derogatory information that required a background investigation. These cases caused a backlog because adequate resources were not available at OPM to perform the reinvestigations or at Oak Ridge to conduct its part of the reinvestigation review.

Obstacles DOE Faces In Implementing New 1985 Requirements

In December 1985, after nearly 2 years of draft review and comment, DOE issued a new Personnel Security Program Order that revised its 1968 order and greatly expanded the scope and depth of the reinvestigations required nationwide. In addition to requiring

requiring 5-year background reinvestigations for about 12,000 Q-sensitive clearance holders, the new order required background reinvestigations for an additional 144,000 Q-nonsensitive and top secret clearance holders, and credit and national agency checks for another 56,000 "L" and secret clearance holders. This policy change resulted in an immediate backlog of about 76,000 employees requiring some type of reinvestigation at Richland, Oak Ridge, Albuquerque, and DOE headquarters. Attachment II shows the impact of the new order at these locations for clearances in effect in July 1986.

Although DOE issued guidance in July 1986 stating that the backlog should be eliminated by 1991, it provided for no additional resources and little guidance on how to reduce the backlog within existing resources. Eliminating the backlog by 1991 will be impossible without a tremendous increase in resources and effort. For example, assuming the current number of cleared personnel, eliminating the clearance backlog, and keeping current with additional clearances coming due for reinvestigations each year will require headquarters and the field offices to greatly increase the numbers of reinvestigations they process. DOE will have to conduct about 24,000 reinvestigations in 1987--up from 4,000 in 1985. The required workload increase at each office ranges from almost 200 percent at headquarters to over 1,100 percent at Albuquerque.

The projected increase in the numbers of needed reinvestigations is only one of several components that may increase the workload of DOE's clearance offices. For example, Oak Ridge's Director of Safeguards and Security told us that alleged drug use information has increased several-fold since January 1984 following introduction of the revised clearance questionnaire. If a similar trend develops at other DOE clearance offices, their workload may also be greatly increased. In addition, investigations that turn up suspected employee drug use may also identify other employees with suspected drug use who will need to be investigated sooner than planned.

DOE has been slow in identifying resource needs and requesting, approving, and providing those resources to address the large workload increase that the December 1985 policy created. For example, during August and September 1986, we discussed with the field offices the expanded workload requirements and their plans for meeting them. None of the offices believed that they could meet the required workload, but none had requested added resources or developed a plan for how they would get current on reinvestigations by 1991. Subsequently, Richland requested three additional clearance employees and Albuquerque requested 13 employees they believed necessary to eliminate the backlog. As of April 1987, Richland had obtained two of the three staff members, but at Albuquerque, the requested staff had not been provided. Furthermore, Oak Ridge had not requested additional staff.

In similar discussions with headquarters clearance officials, we were told that requests had been made to fill two vacant positions and hire four additional staff. They received approval to fill the vacancies and also to obtain temporary help from OPM. Five OPM employees have been temporarily assigned to DOE for 4 months. The first vacancy was filled when DOE transferred one individual in January 1987 to administer the contractor reinvestigation program. The second vacancy had not been filled at the completion of our work, and the request for four additional staff has not been acted on.

Another way to address the expanded workload is to reduce the numbers and levels of clearances. Some DOE actions have shown that this may be possible. For example, in response to a July 1986 report from DOE's Inspector General, DOE terminated 3,000 of over 16,000 active clearances at headquarters for employees no longer affiliated with DOE. Similarly, Richland reviewed its clearance files and terminated over 2,000 of about 16,000 clearances. Albuquerque and Oak Ridge clearance officials told us they are also taking steps to eliminate unwarranted clearances from their files.

In addition, DOE has identified other methods to reduce the reinvestigation workloads, such as downgrading clearances and reducing the area in some buildings in which only cleared employees are permitted. So far, little progress has been made in reducing clearances from these efforts. For example, Richland is waiting for funding to reduce the size of classified areas in one building.

In summary, Mr. Chairman, our March 1987 report to you identified a number of problems with DOE's security clearance reinvestigation program. Therefore, we recommended that the Secretary of Energy develop a plan to bring headquarters and the field offices into compliance with the December 1985 Personnel Security Program Order. The plan should consider (1) reinvestigation workload requirements, and (2) resources needed to meet those requirements.

Because the reinvestigation workload is directly related to the numbers and levels of active clearances, the first step in the planning process should focus on how those numbers and levels can be reduced. DOE may be able to reduce clearance numbers and levels by ensuring that only employees who require clearances have them, that employees have the lowest clearance level needed to do their jobs, and that clearances for individuals who are no longer associated with DOE are promptly terminated. The results of our ongoing work on the remainder of DOE's security clearance activities may provide more specific suggestions for reducing clearance numbers and levels.

In addition, the Secretary should direct the Assistant Secretary for Defense Programs to review and approve the plan, monitor its implementation, and annually report to him on compliance with DOE directives. This hearing will provide an excellent opportunity for your subcommittee to explore our recommendations with DOE officials, as well as what they can do to expedite their reinvestigation workload.

- - - - -

This concludes my testimony. We would be pleased to respond to any questions you or members of the Subcommittee may have.

CLEARANCE LEVELS AND TYPES OF REINVESTIGATION REQUIRED

Clearance level	Reinvestigation requirements prior to December 1985[a]	Reinvestigation requirements after December 1985
Q sensitive	FBI background reinvestigation after 5 years. FBI file and fingerprint check every 5 years thereafter.	FBI background reinvestigation after 5 years. National agency and credit check after 10 and 15 years. FBI background reinvestigation after 20 years. National agency and credit check every 5 years thereafter.
Q nonsensitive (With special access)	OPM background reinvestigation after 5 years. FBI file and fingerprint check every 5 years thereafter.	OPM limited background reinvestigation after 5 years. National agency and credit check after 10 and 15 years. OPM special background reinvestigation after 20 years. National agency and credit check every 5 years thereafter
Other Q nonsensitive	DOE review of updated personnel security questionnaire every 5 years.	Same as above for all Q nonsensitive clearances.
L	DOE review of updated personnel security questionnaire every 5 years.	National agency and credit check after 5 years. DOE review of updated personnel security questionnaire plus FBI file and fingerprint check after 10 and 15 years. National agency and credit check after 20 years..DOE review of updated personnel security questionnaire and FBI file and fingerprint check every 5 years thereafter.
Top Secret	None.	Same as Q nonsensitive.
Secret	None.	Same as "L."

[a] DOE's Deputy Director for Security interpretation of requirements.

CLEARANCES BY TYPE AT FOUR OFFICES COVERED

	Types of clearances					
Location	**Q sensitive**	**Q nonsensitive**	**L**	**Top secret**	**Secret**	**Total**
DOE headquarters	3,685	7,593	1,085	189	1,016	13,568
Richland	245	10,516	3,828	0	7	14,596
Oak Ridge	1,290	34,396	6,906	243	1,352	44,187
Albuquerque	3,831	44,017	998	2	14	48,862
Total	**9,051**	**96,522**	**12,817**	**434**	**2,389**	**121,213**

Impact of DOE's December 1985 Reinvestigation Policy on Clearances in Effect in July 1986[a]

Location	**Clearances requiring reinvestigations under 1983 policy[b]**	**Clearances requiring reinvestigations under 1985 policy**	**Backlog which policy created**
Richland	244	14,561	6,911
Oak Ridge	1,282	43,985	29,940
Albuquerque	3,817	48,756	33,314
DOE headquarters	2,936	7,577	3,434
Total	**8,279**	**114,879**	**73,599**

[a] All data in this table are taken from information DOE provided its field offices in July 1986 and is intended to show the increase in clearance workload solely attributable to the December 1985 reinvestigation policy. Data exclude clearances for other government agency employees.

[b] As discussed earlier, Richland, Oak Ridge, and DOE headquarters did not meet these quotas.

United States General Accounting Office

GAO

Testimony

For Release
on Delivery
Expected at
9:30 a.m. EST
Wednesday
March 25, 1987

Environmental, Safety, and Health Oversight of the Department of Energy's Operations

Statement of
Keith O. Fultz, Associate Director
Resources, Community, and Economic
Development Division

Before the
Subcommittee on Natural Resources,
Agriculture Research, and Environment

Committee on Science, Space, and
Technology
House of Representatives

GAO/T-RCED-87-12

Mr. Chairman and Members of the Subcommittee:

We are pleased to be here today to discuss the General Accounting Office's (GAO) views on the need for better oversight of certain activities conducted by the Department of Energy (DOE). Over the last several years, GAO has issued over 20 reports (see attachment I) that address various environmental, safety, and health (ES&H) aspects of DOE's nuclear defense complex. These reports have identified problems and issues at individual facilities as well as throughout the entire DOE system.

Collectively, our work presents three basic messages. First, DOE needs to upgrade and strengthen its own internal ES&H oversight programs. In the past year and a half, DOE has implemented initiatives aimed at improving and strengthening its own internal oversight programs. These initiatives are a positive step. We believe, however, that it is too early to judge their effectiveness because many have not yet been completed.

Second, we identified a need for outside, independent assessments in two areas--reviewing safety analysis reports and inspecting waste disposal practices. Such assessments would provide more assurance to the Congress and the public that DOE facilities are operated in a safe and environmentally acceptable manner.

Finally, DOE needs to provide the Congress and the public with a comprehensive picture of the environmental situation at its facilities. Our reports have shown extensive environmental problems, such as groundwater and soil contamination, at many DOE facilities around the country. Also, many DOE facilities are not in full compliance with environmental laws.

Our country faces huge expenditures to clean up waste sites at many facilities as well as to construct new facilities for waste treatment and disposal. Furthermore, some of DOE's sites may be irreversibly contaminated and may require long-term institutional care. With these problems in mind, we have made two major recommendations. First, DOE needs to develop a groundwater and soil protection strategy. Second, we believe DOE needs to provide the Congress with a comprehensive report on its plans, milestones, and cost estimates to bring its facilities into full compliance with environmental laws. This analysis would be a key component in an overall strategic plan for DOE's nuclear defense complex, which Mr. J. Dexter Peach, Assistant Comptroller General, called for on March 12, 1987, in testimony before the Senate Governmental Affairs Committee.

I would now like to discuss our three basic messages in more detail.

NEED TO UPGRADE AND STRENGTHEN DOE INTERNAL OVERSIGHT PROGRAM

Since the early 1980's, GAO has issued a number of reports that have identified important environmental, safety, and health problems needing corrective action. These reports have also identified several weaknesses in DOE's oversight program. In a 1981 report[1] and again in a 1983 report,[2] we pointed out that DOE's oversight program's structure within DOE was one underlying cause of the program's shortcomings. In those two reports, we argued for a separate office within DOE specifically set up to oversee ES&H matters and recommended that this office should report to the Under Secretary.

In September 1985, DOE, in effect, adopted our early 1980 recommendations and established an Office of Assistant Secretary for Environment, Safety, and Health, who reports to the Under Secretary. At that time DOE also announced a number of other initiatives aimed at strengthening its own internal ES&H programs. Some of the more important initiatives announced were (1) revising DOE orders that govern the conduct of DOE's ES&H activities and (2) conducting safety appraisals and environmental surveys at DOE facilities and sites. We believe the initiatives are a positive step. Our monitoring of DOE's implementation of these initiatives shows DOE is making progress--virtually all the initiatives are underway. We will continue to monitor DOE's efforts in this area.

---

[1] Better Oversight Needed for Safety and Health Activities at DOE's Nuclear Facilities (EMD-81-108; August 1981).

[2] DOE's Safety and Health Oversight Program at Nuclear Facilities Could Be Strengthened (GAO/RCED-84-50; November 1983).

OUTSIDE INDEPENDENT ASSESSMENTS

Although the September 1985 initiatives are a step in the right direction, we believe there is no substitute for outside, independent oversight in certain areas. In two of our recent reports, we identified areas that we believe warrant such outside oversight.

In June 1986,[3] we reported on DOE safety analysis reports for eight of DOE's operating facilities. These reports are important documents that DOE uses to show that its facilities are safely designed, constructed, and operated. We found that DOE has not approved some safety reviews, some provided little or no comparison to design criteria, and some used different approaches to analyze serious accidents. We also noted DOE's safety analysis process is an internal DOE function carried out primarily by DOE field offices. Because an effective and well-accepted safety review process is the key to demonstrating that a nuclear facility can be operated safely, we made a number of recommendations to ensure DOE has a credible safety review process. One recommendation was that DOE make arrangements with an outside, independent organization to review the safety analysis reports for DOE's most hazardous facilities. We continue to believe that such outside independent reviews would better assure the Congress and the public that DOE's facilities are safe.

---

[3] Safety Analysis Reviews for DOE's Defense Facilities Can Be Improved (GAO/RCED-86-175; June 1986).

In a September 1986 report,[4] we discussed environmental issues at nine DOE defense facilities. We found many problems that could be traced back to the way DOE disposes of hazardous and radioactive waste. These included extensive groundwater and soil contamination (which was very high in some areas). Although DOE is subject to regulation by the states and/or the Environmental Protection Agency (EPA) for disposing of its hazardous waste, we are concerned that some portion of DOE's mixed waste (waste containing both hazardous and radioactive material) may be exempt from regulation by the state and/or EPA, and, therefore, its disposal would not be subject to outside inspection. In our view, independent inspections of waste disposal practices are needed to ensure that such wastes will be disposed of in an environmentally acceptable manner. Our report recommended that DOE allow for outside, independent inspection of the disposal practices used for any mixed waste it self-regulates.

---

[4] Environmental Issues At DOE's Nuclear Defense Facilities (GAO/RCED-86-192; September 1986).

In the case of outside review for safety analysis, DOE believes that its own Office of Assistant Secretary for Environment, Safety, and Health provides sufficient independent review. In its August 21, 1986 response to our recommendation, DOE stated

> ". . .an additional level of oversight, over and above that already existing under the guidance of the Assistant Secretary for Environment, Safety, and Health, would not provide any additional assurances of the safe operations of DOE facilities. . . ."

With regard to outside independent inspection of waste sites, DOE has not yet given us a position. DOE is currently negotiating with EPA to characterize those mixed wastes that will be subject to regulation. DOE officials told us they would respond to our recommendation when these negotiations are completed.

DOE's reluctance to adopt our recommendation for outside, independent oversight, is quite frankly, difficult to understand. DOE, on occasion, does use such outside reviews--some of which have caused DOE to modify its activities at its production reactors. For example, when faced with safety concerns about the N-reactor (Washington State) because of its design similarity to the Chernobyl reactor, DOE sought outside help from six consultants--the Roddis panel. After receiving the panel results, DOE temporarily shut down the N-reactor ahead of schedule to upgrade safety systems. DOE has also requested the National Academy of Sciences to review the three DOE production reactors at Savannah River. On March 9, 1987, the Academy raised concerns about the adequacy of the reactors' emergency cooling system in handling a serious loss-of-coolant accident while operating at the current power limits. The power limits for these reactors had already been reduced in November and December 1986 for safety reasons. On the basis of the Academy's concerns, DOE on March 20, 1987, reduced the operating power limits further to about 50 percent of capacity. DOE is now studying this problem.

DOE's general reluctance to allow for outside independent reviews also has important implications. First, there is no outside, independent scrutiny on a continuing basis. The Congress and the public must therefore, rely heavily on DOE's information and views for ensuring safety, which may not be the same as an outside group's. Second, there is the potential for conflict between production goals and safety functions. Finally, self-regulation provides only a minimum level of public assurance that these facilities can safely operate. This minimum level, I believe, is becoming more unacceptable to the Congress and the public as more problems and issues surface in the DOE nuclear defense complex.

THE NEED FOR A COMPREHENSIVE PICTURE OF THE ENVIRONMENTAL SITUATION AT DOE FACILITIES

The last overall message that GAO has tried to convey over the past few years is a need for a comprehensive picture of and solution to existing environmental problems. We have identified significant issues that warrant solutions because of health and safety concerns--such solutions will cost the billions of dollars. If not corrected, these problems can have a long-lasting effect on the environment and pose a health threat to the general public.

In our September 1986 report,[5] we reported that DOE operations have contaminated groundwater at eight of the nine facilities reviewed. In many cases, the contamination included both hazardous and radioactive material and was at levels hundreds to thousands of times greater than drinking water standards. We also noted that at a few sites some contamination had migrated off-site, into rivers and into drinking water aquifers. We are concerned that the contamination can pose a health threat when it migrates into drinking water sources. Further, we found that soil contamination existed at six of the nine facilities. Thus, we recommended that DOE develop a groundwater and soil protection strategy.

---

[5] Environmental Issues at DOE's Nuclear Defense Facilities (GAO/RCED-86-192; September 1986).

In this same report, we found that four of the nine facilities were not in full compliance with the Clean Water Act, and none had final permits for disposing of waste under the Resource Conservation and Recovery Act. As a result, at some facilities, DOE is discharging waste, above state limits, into rivers and streams and is continuing to dispose of waste in a manner that adds to the groundwater contamination.

In a review of the waste disposal practices at DOE's Hanford facility in Washington State, we found that Hanford[6] had been slow to identify all units that should be regulated under the Resource Conservation and Recovery Act, and it has not identified all potential Comprehensive Environmental Response, Compensation, and Liability Act ("Superfund") waste sites that may require corrective actions.

Furthermore, in a March 1986 report,[7] we addressed DOE's plans to dispose of transuranic waste--discarded tools, rags, and paper containing man-made radioactive elements--which remains dangerous for thousands of years and presents a health hazard if inhaled, ingested, or absorbed into the body through an open wound. Basically, DOE set forth a plan to put this waste into a geological repository. We found, however, that DOE planned to send only about 19 percent of its transuranic waste inventory to the repository. DOE was noncommittal regarding the permanent disposition of the remaining 81 percent. Since this waste is buried only a few feet underground, it can pose environmental and/or health problems if it is disturbed or migrates.

---

[6] Unresolved Issues Concerning Hanford Waste Management Practices (GAO/RCED-87-30; November 1986).

[7] DOE's Transuranic Waste Disposal Plan Needs Revision (GAO/RCED-86-90; March 1986).

The cost of dealing with environmental problems at DOE facilities will be substantial. Because so many uncertainties exist--DOE has not fully identified its problems and/or the solutions to correct them--the total cost estimates to address the environmental concerns are not known. However, it will take billions of dollars just for DOE to comply with environmental laws. In addition, DOE plans to spend billions of dollars to dispose of high-level and transuranic waste in geologic repositories. Accordingly, we have recommended that DOE provide the Congress with a comprehensive report on its plans, milestones, and cost estimates to bring its facilities into full compliance with environmental laws. DOE agreed with this recommendation and believes that completion of its environmental surveys and other on-going environmental actions will enable it to prepare an overall long-range plan.

SUMMARY

The establishment of an Office of Assistant Secretary for Environment, Safety, and Health was a positive step. However, we still see the need for outside, independent oversight. In this regard, we have identified two areas where such oversight is needed--reviewing safety analysis reports and inspecting waste disposal sites that may be exempt from outside regulation. We believe outside oversight in these areas would enhance the internal oversight provided by the Assistant Secretary.

In the environmental protection area, we have recommended that DOE develop (1) a groundwater and soil protection strategy and (2) a comprehensive plan for bringing DOE facilities into full compliance with environmental laws. We believe the Office of Assistant Secretary for Environment, Safety, and Health can play an important role in developing both the strategy and plan. DOE has accepted these recommendations but has not yet fully implemented them.

I hope this Subcommittee has the opportunity to explore with DOE officials their views on the need for outside, independent oversight as well as when our recommendations on environmental issues will be fully implemented and how they plan to expedite their completion. This should help provide the Congress and the public with a clearer understanding of the environmental risks associated with operating DOE's nuclear defense activities.

- - - - -

This concludes my testimony. We would be pleased to respond to any questions you or Members of the Subcommittee may have.

GAO REPORTS RELATED TO ENVIRONMENTAL, SAFETY, & HEALTH ASPECTS OF DOE OPERATIONS

NUCLEAR WASTE: Unresolved Issues Concerning Hanford's Waste Management Practices (GAO/RCED-87-30; Nov. 1986)

NUCLEAR ENERGY: Environmental Issues at DOE's Nuclear Defense Facilities (GAO/RCED-86-192; Sept. 1986)

NUCLEAR SAFETY: Comparison of DOE's Hanford N-Reactor With the Chernobyl Reactor (GAO/RCED-86-213BR; Aug. 1986)

NUCLEAR WASTE: Impact of Savannah River Plant's Radioactive Waste Management Practices (GAO/RCED-86-143; July 1986)

NUCLEAR ENERGY: A Compendium of Relevent GAO Products on Regulation, Health, and Safety (GAO/RCED-86-132; June 1986)

NUCLEAR SAFETY: Safety Analysis Reviews for DOE's Defense Facilities Can Be Improved (GAO/RCED-86-175; June 1986)

ENVIRONMENT, SAFETY, & HEALTH: Status of Department of Energy's Implementation of 1985 Initiatives (GAO/RCED-86-68FS; Mar. 1986)

NUCLEAR WASTE: Department of Energy's Transuranic Waste Disposal Plan Needs Revision (GAO/RCED-86-90; Mar. 1986)

ENVIRONMENT, SAFETY, & HEALTH: Environment and Workers Could Be Better Protected at Ohio Defense Plants (GAO/RCED-86-61; Dec. 1985)

ENVIRONMENT, SAFETY & HEALTH: Information on Three Ohio Defense Facilities (GAO/RCED-86-51FS; Nov. 1985)

DOE's Plutonium Facility (GAO/RCED-85-3; Sept. 1985)

Department of Energy Acting To Control Hazardous Waste At Its Savannah River Nuclear Facilities (GAO/RCED-85-23; Nov. 1984)

DOE's Safety and Health Oversight Program At Nuclear Facilities Could Be Strengthened (GAO/RCED-84-50; Nov. 1983)

Decommissioning Retired Nuclear Reactors At Hanford Reservation (GAO/RCED-83-104; Apr. 1983)

Cleaning Up Nuclear Facilities--An Aggressive and Unified Federal Program Is Needed (GAO/EMD-82-40; May 1982)

GAO's Response to DOE on EMD-81-108, "Better Oversight Needed for Safety and Health Activities at DOE's Nuclear Facilities" (EMD-82-36; Jan. 1982)

Congress Should Increase Financial Protection to the Public From Accidents at DOE Nuclear Operations (EMD-81-111; Sept. 1981)

Better Oversight Needed For Safety and Health Activities At DOE's Nuclear Facilities (EMD-81-108; Aug. 1981)

GAO's Analysis of Alleged Health and Safety Violations At The Navy's Power Training Unit At Windsor, Connecticut (EMD-81-19; Nov. 1980)

Department of Energy's Safety and Health Program For Enrichment Plant Workers Is Not Adequately Implemented (EMD-80-78; July 1980)

Decommissioning Hanford Reactor (EMD-79-20; Jan. 1979)

United States General Accounting Office

GAO

Testimony

For Release
on Delivery
Expected at
9:30 a.m. EST
Tuesday
March 17, 1987

Environmental Aspects of the Department of Energy's Nuclear Defense Activities

Statement of
Keith O. Fultz, Associate Director
Resources, Community, and Economic Development
Division

Before the
Committee on Governmental Affairs
United States Senate

GAO/T-RCED-87-7

Mr. Chairman and Members of the Committee:

We are pleased to be here today to discuss the General Accounting Office's (GAO) work concerning environmental aspects at the Department of Energy's (DOE) nuclear defense facilities. Over the past 2 years, GAO has issued six reports--many prepared at your request, Mr. Chairman--concerning environmental issues and problems within the DOE nuclear defense weapons complex. These reports have identified problems at individual facilities as well as systemic issues facing DOE.

Our major concerns are that DOE's operations (1) have contaminated groundwater and soil with high levels of both radioactive and hazardous substances and (2) do not fully comply with environmental laws. We believe both situations have occurred because DOE has not given sufficient emphasis to environmental protection at its facilities. DOE will have to spend billions of dollars to acquire the necessary environmental permits, change some of its operating and disposal practices, and cleanup existing contamination. We also believe that some of DOE's sites may be irreversibly contaminated and may require long-term institutional control. Finally, DOE has not defined the full scope of its environmental problems, the corrective actions needed, and the costs and time frames to resolve them.

We have recommended that DOE (1) provide the Congress a comprehensive report on its plans, milestones, and cost estimates to bring its facilities into full compliance with applicable environmental laws and (2) develop an overall groundwater and soil protection strategy. We believe that once DOE fully implements these recommendations, the Congress and DOE will have a better perspective on the environmental risks and impacts of DOE's operations and of the budgetary implications, and time frames associated with the cleanup activities required. Comprehensive information on environmental problems and an overall groundwater and soil protection strategy would be key components in the overall strategic plan for DOE's nuclear defense complex that Mr. J. Dexter Peach, Assistant Comptroller General, called for in his testimony before this Committee last Thursday (March 12, 1987).

Before I highlight some of the environmental problems we have identified and the actions DOE needs to take to correct them, I will provide you a brief overview of DOE's environmental compliance responsibilities.

DOE'S ENVIRONMENTAL COMPLIANCE RESPONSIBILITIES

DOE's primary mission is to produce nuclear material (plutonium and tritium) for weapons and naval fuel. This mission is carried out at numerous facilities at 18 sites around the nation--many of which were built more than 30 years ago. DOE's operations routinely use and generate large quantities of a variety of hazardous and radioactive substances. These substances must be handled, transported, and disposed of carefully, not only to prevent worker exposures but also to prevent their release to the environment. Many of the substances contain lethal levels of radiation that must be handled with special equipment.

DOE's policy calls for conducting its operations in an environmentally safe manner. For example, the policy states that its facilities should comply with both radioactive and nonradioactive air emission standards established by the Environmental Protection Agency pursuant to the Clean Air Act. With regard to liquid emissions, DOE regulates itself for the amount and type of radioactive material released but is subject to the Clean Water Act for nonradioactive releases. To do this, DOE's facilities obtain National Pollutant Discharge Elimination System permits from states.

DOE also generates both radioactive and hazardous waste. Until 1984 DOE self-regulated all its waste activities. In 1984, however, a U.S. district court ruled that DOE's hazardous waste was subject to the Resource Conservation and Recovery Act. As a result, DOE must now comply with federal and state regulations in handling and disposing of hazardous waste.

MAJOR ENVIRONMENTAL ISSUES IDENTIFIED IN GAO REPORTS

Let me briefly summarize our work over the past 2 years that has identified a number of environmental issues and problems at numerous DOE facilities. These reports have resulted in several recommendations.

Information on Three Ohio Defense Facilities (GAO/RCED-86-51FS, November 1985) and Environment and Workers Could Be Better Protected at Ohio Defense Plants (GAO/RCED-86-61, December 1985)

In these reports, prepared at your request, we assessed a number of environmental issues at three DOE plants--Fernald, Mound, and Portsmouth--in Ohio. We found that during the 1970's, DOE considered closing the antiquated Fernald facility. As a result, it did not make capital improvements, and equipment deteriorated. In the early 1980's, DOE's production goals increased, putting a strain on the plant's resources. According to DOE documents, Fernald's management emphasized production over environmental concerns, and between September and December 1984, the plant released about 273 pounds of slightly-enriched uranium into the air. In addition, DOE's inattention to appropriate controls over water runoff from the plant resulted in uranium contamination in three off-site wells, one of which was used for drinking water.

Further, between 1959 and 1969, DOE's Mound facility released large quantities of radioactive tritium into the air and water. In 1970, Mound found tritium contamination in a community drinking water aquifer. At that time, the concentration was within standards, but in 1976 the standards changed, and Mound instituted dilution activities for the aquifer, which are continuing today. Because our work validated previous recommendations that DOE had not adopted, we again made recommendations to DOE concerning radiological monitoring guides and independent verification of contractor data. DOE concurred with our recommendations and expects to have them implemented this year.

Impact of Savannah River Plant's Radioactive Waste Management Practices (GAO/RCED-86-143, July 1986)

This report represented a site-wide assessment of radioactive waste management practices at DOE's Savannah River facility. Although we did not identify any off-site contamination above applicable standards, we found that DOE's operations at that facility have caused extensive on-site groundwater and soil contamination--some of which DOE may never be able to rectify. For example, plant operations have contaminated streams on the plant site; the radioactive contamination in one stream was about 750 times greater than drinking water standards. They have also contaminated groundwater--some concentrations were about 116,000 times greater than drinking water standards. In addition, leaks from high-level waste storage tanks have contaminated about 30,000 square feet of soil underlying the tanks. As a result of the contamination at the facility, the possibility exists that some radioactive contamination could reach the Tuscaloosa aquifer. In addition, because of the extensive contamination, institutional controls and oversight at the facility may be needed for hundreds of years.

Environmental Issues at DOE's Nuclear Defense Facilities (GAO/RCED-86-192, September 1986)

This report examined environmental conditions at nine DOE facilities nationwide and found that groundwater and soil have been contaminated at most of these facilities. At eight facilities, the groundwater has been contaminated to high levels with hazardous and/or radioactive material (attachment I). For example, DOE facilities in Colorado, South Carolina, and Tennessee contaminated the groundwater with solvents (cleaning agents) that are as much as 1,000 times above proposed drinking water standards. Other DOE facilities in South Carolina and Washington State contaminated the groundwater with radioactive materials that are more than 400 times greater than drinking water standards. At Mound and Fernald in Ohio, the contamination has migrated off-site into drinking water supplies--both a well and an aquifer. In addition, DOE's Savannah River operations have contaminated a drinking water aquifer underlying the site. State officials are concerned that the existing contamination may pose a public health threat and that DOE is adding to the contamination by continuing to discharge radioactive and hazardous material into the environment.

DOE's operations had also contaminated soil at six facilities (attachment II). At some sites--the Y-12 plant in Oak Ridge, Tennessee, Mound and Fernald in Ohio, and Rocky Flats in Colorado--the contamination had migrated off-site. Of the off-site contamination problems, the Y-12 plant poses a significant public health threat. Mercury from that plant's operations contaminated a stream bed and a flood plain. In some locations, the contamination is greater than 2,000 times background levels and over 150 times greater than the state's public health guidelines. To make matters worse, contaminated soil from the flood plain was used in various construction projects around the town of Oak Ridge. In addition, off-site plutonium contamination of the soil at Mound may endanger public health if it is disturbed.

Although DOE has projects underway to clean up both the groundwater and soil contamination at a few facilities, it continues to study the extent, type, and movement of the contamination at other facilities. However, these problems have existed for many years--some for as long as 20 years. Therefore, we recommended that DOE develop an overall groundwater and soil protection strategy to provide the Congress and the public a better perspective on the environmental risks associated with DOE's facilities.

We also found that four DOE facilities are not in full compliance with the Clean Water Act. For example, in 1980 the state required DOE to construct four new projects at the Fernald, Ohio, plant in order to meet Clean Water Act requirements. As of March 1987, one of these projects had not been completed. In addition, DOE believes that one project may not adequately treat the waste in the manner originally anticipated, thus DOE may have to take additional actions to bring Fernald into full compliance with the Clean Water Act.

With regard to the Resource Conservation and Recovery Act, we noted that none of the nine facilities has received a final permit. This act requires that waste be appropriately protected, from generation through its ultimate disposal, primarily to prevent groundwater contamination. Until DOE's facilities receive the required permits, which could take many years, they continue to dispose of waste in a manner that may add to groundwater contamination. As a result, we recommended that DOE develop a comprehensive plan that sets out its plans, milestones, and cost estimates to bring its facilities into full compliance with applicable environmental laws and provide the Congress and public assurance that the waste will be disposed of in an environmentally acceptable manner. We also recommended that DOE allow outside, independent inspection of the disposal practices used for any waste DOE self-regulates.

Unresolved Issues Concerning Hanford's Waste Management Practices
(GAO/RCED-87-30, November 1986)

We found that DOE's Hanford, Washington, facility discharged liquid waste directly into the soil, although federal and state regulators would not allow private entities to do this without protective liners and proper monitoring. For example, in 1985, Hanford disposed of over 25 million gallons of contaminated (both radioactive and hazardous) waste to an unlined disposal site and did not meet groundwater monitoring requirements for the site. Hanford instituted changes in July 1986 to reduce the level of contamination in the waste discharged and plans further changes--expected to be in place by 1989--to its operations to lessen the problem. Until this system is in place, Hanford could continue to discharge contaminated waste into the soil in a manner that may not comply with environmental laws.

We also found that Hanford had been slow to identify all units that should be regulated under the Resource Conservation and

Recovery Act, and it has not identified all potential Comprehensive Environmental Response, Compensation, and Liability Act ("Superfund") sites that may require corrective actions. As a result, Hanford does not know, nor can it ensure the regulatory agencies, that it manages and disposes of waste in compliance with these environmental waste statutes. Therefore, we recommended that DOE identify all current and previously-used waste treatment, storage, and disposal sites, and the corrective actions required for each. DOE concurred with this recommendation and expects to complete this effort by August 1987.

DOE's Transuranic Waste Disposal Plan Needs Revision (GAO/RCED-86-90, March 1986)

In this report, we discussed the disposal of transuranic waste that DOE generates at many facilities across the country. Transuranic waste--discarded tools, rags, and paper, containing man-made radioactive elements--remains dangerous for thousands of years and presents a health hazard if inhaled, ingested, or absorbed into the body through an open wound. Although DOE has a multi-billion dollar effort to put this waste 2,150 feet underground in a geological repository in New Mexico, it only expects to send about 19 percent of the existing waste there. DOE has made no commitment regarding the permanent disposal of the remaining 81 percent that is currently at six locations around the country. Since this waste is only a few feet underground (25 feet below the surface at most), it can pose environmental and/or health problems if it is disturbed or if it migrates. If DOE ultimately decides to keep this waste in place, it may have to institute remedial actions to immobilize the waste to ensure it does not migrate to the groundwater and/or contaminate adjacent soil. Since DOE has not addressed these issues, we recommended that it provide the Congress with complete information on its plans and costs to permanently dispose of this waste. DOE concurred with the recommendation and expects to complete a report on these issues by June 1987.

FUTURE COSTS UNCERTAIN BUT WILL BE IN THE BILLIONS

The cost of dealing with environmental problems at DOE facilities will be substantial. Because so many uncertainties exist--DOE has not fully identified its problems and/or the solutions to correct them--the total cost estimates to address the environmental concerns are not known. However, it will take billions of dollars for DOE to comply with environmental laws. In addition, DOE plans to spend billions of dollars to dispose of high-level and transuranic waste in geologic repositories. To provide a perspective of some identified costs to date, we have summarized some examples from our previously issued reports.

At three facilities we reviewed (Fernald and Mound in Ohio and Y-12 in Tennessee), DOE plans to spend over $60 million to bring them into compliance with the Clean Water Act. In addition, to get final Resource Conservation and Recovery Act permits for nine facilities, DOE plans to change its disposal operations at an estimated cost of $200 million.

The eventual cost for corrective actions at all of DOE's facilities will be much higher, depending on the site-specific environmental problems that DOE will have to resolve. For example, DOE is studying ways to reduce, eliminate, or recycle low-level radioactive liquid waste rather than discharge it directly into the soil. One study conducted at Hanford estimates that alternative disposal methods could cost up to $500 million. Further, groundwater cleanup and monitoring costs can easily amount to hundreds of millions of dollars at a single site. In addition, DOE may have to modify existing facilities to meet requirements under the Clean Water Act. For example, it is examining alternatives to reduce the temperature of the water discharged from the N-reactor. One alternative is estimated to cost $150 million.

With regard to radioactive waste disposal, DOE expects to spend over $4.6 billion to dispose of about 19 percent of its transuranic waste in a geologic repository. DOE officials could not provide cost estimates for the permanent disposal of the remaining 81 percent but believe the costs could be substantial, depending on the disposal method selected. In addition, DOE estimates it will cost from $491 million to $6.4 billion (depending on the method selected) to dispose of high-level radioactive waste from 149 single-walled tanks at Hanford.

In summary, although a complete estimate is not available, the eventual cost to bring the DOE facilities into full compliance with environmental laws and to dispose of waste will clearly be in the billions of dollars.

SUMMARY

In testimony given last Thursday, Mr. J. Dexter Peach called for an overall strategic plan for the entire DOE nuclear defense complex that sets forth the following: projected facility requirements for continued nuclear weapons production; a comprehensive picture of the environmental, safety, and health issues facing DOE; and solutions to resolve them. In my testimony today, I am reiterating the need for two environmental actions that we have previously recommended to DOE. These items would be an integral part of this overall strategic plan. They are (1) an overall groundwater and soil protection strategy and (2) a comprehensive plan to bring DOE facilities into full compliance with environmental laws.

DOE has accepted these recommendations, but we do not know when they will be fully implemented. I hope that the Committee has the opportunity to explore with DOE officials at these hearings when our recommendations will be fully implemented. Only then will the Congress and the public have a clear understanding of the environmental risks associated with operating DOE's nuclear defense activities.

- - - - -

This concludes my testimony. We would be pleased to respond to any questions you or Members of the Committee may have.

Groundwater Contamination at Selected DOE Facilities[a]

Facility	Major type(s) of contamination	Level of contamination
Feed Materials Production Center, Ohio	nitrates and chloride	Nitrates and chloride have been reported above drinking water standards.
Fuel fabrication plant, South Carolina	solvents[b] and nitrates	Solvents have been reported at levels over 30,000 times the proposed drinking water standards. Nitrates have been reported at levels over 10 times the drinking water standards.
Los Alamos National Laboratory, New Mexico	none[c]	No contaminants resulting from the laboratory's operations have been reported that exceed drinking water standards.
Mound Laboratory, Ohio	tritium[d]	Although in 1976 tritium concentrations were above the drinking water standards, continual remedial actions keep the levels below the standards.
N-Reactor, Washington State	strontium-90,[e] tritium, and nitrates	Strontium-90 has been detected at levels over 400 times higher than the drinking water standards. Tritium and nitrates are slightly above drinking water standards.
Rocky Flats plant, Colorado	solvents, cadmium, and selenium	Solvents have been reported as high as 1,000 times the proposed drinking water standards. Cadmium and selenium have been detected at or slightly above the drinking water standards.
Reprocessing plant, South Carolina	tritium, nitrates, and mercury	Tritium has been reported over 2,500 times the drinking water standards. Nitrates and mercury have been detected at levels slightly above drinking water standards.
Reprocessing plant, Washington State	tritium, iodine-129,[f] and nitrates	Tritium concentrations have been reported over 25 times higher than the drinking water standards. Iodine-129 and nitrates have both been reported above the drinking water standards.
Y-12 plant, Tennessee	Solvents, nitrates, mercury, arsenic, and chromium	Solvents have been detected over 1,000 times greater than proposed drinking water standards. Nitrate concentrations have been reported at levels 1,000 times the drinking water standards. Mercury has been detected at levels 500 times the drinking water standards. Arsenic has been detected at levels 60 times the drinking water standards. Chromium has been detected at levels over 30 times the drinking water standards.

[a] The table shows only major contaminants (e.g., those that exceed existing and/or proposed drinking water standards). At many facilities other contaminants are in the groundwater above background levels.

[b] Solvents are cleaning agents, such as trichloroethylene; 1,1,1, trichloroethane; and/or tetrachloroethylene. These are classified as hazardous waste and toxic pollutants.

[c] According to DOE, at this facility arsenic and flouride occur naturally in the groundwater.

[d] Tritium is a radioactive isotope of hydrogen. It has a half-life of 12.5 years.

[e] Strontium-90 is a radioactive isotope of strontium with a half-life of 30 years.

[f] Iodine-129 is a radioactive isotope of iodine with a half-life of over 15 million years.

Soil Contamination at Selected DOE Facilities

Facility	Description of unplanned soil contamination
Feed Materials Production Center, Ohio	Elevated levels of uranium both on- and off-site. Data indicate that elevated levels are, in some places, more than 10 times background levels.
Mound Laboratory, Ohio	Elevated levels of plutonium both on- and off-site. Data indicate that the levels are, in some instances, more than 100 times background levels.
Rocky Flats plant, Colorado	Elevated levels of plutonium both on- and off-site. Data indicate that the levels are, in some places, more than 50 times background levels.
Reprocessing plant, South Carolina	Elevated levels of plutonium on-site. Levels recorded were slightly higher than 10 times background levels. Soil under a high-level waste tank has become radioactive.
Reprocessing plant, Washington State	Soil under some high-level waste tanks has become radioactive.
Y-12 plant, Tennessee	Off-site mercury contamination greater than 2,000 times background levels has been recorded

United States General Accounting Office

GAO

Testimony

For Release
on Delivery
Expected at
9:30 a.m. EST
Thursday
March 12, 1987

Environmental, Safety, and Health Aspects of the Department of Energy's Nuclear Defense Complex

Statement of
J. Dexter Peach, Assistant Comptroller General
Resources, Community, and Economic Development
Division

Before the
Committee on Governmental Affairs
United States Senate

GAO/T-RCED-87-4

Mr. Chairman and members of the Committee:

We are pleased to be here today to provide an overview of the General Accounting Office's (GAO's) work on environmental, safety, and health aspects of the Department of Energy's (DOE's) nuclear defense complex. Over the past several years GAO has issued over 20 reports (see attachment I), many prepared at your request, Mr. Chairman, on various aspects of the DOE nuclear defense complex.

These reports have described a variety of unresolved safety and environmental problems at DOE's nuclear defense facilities. But, more importantly, when considered together, they underline a series of critical issues that the Congress and the Administration need to face in determining the future of the DOE nuclear weapons complex.

These issues arise because (1) many of the facilities are old and some are already operating beyond their expected life, (2) unresolved concerns exist about the operational safety of many of the facilities, and (3) the lack of attention to environmental problems created by facility operations over the years has created an undefined backlog of clean-up actions needed. The cost of remodeling or building new facilities will be in the billions, as will the cost of bringing facilities into compliance with environmental laws. What the Congress needs from DOE is an overall strategic plan which defines the universe of problems it faces in rebuilding its nuclear defense complex. This strategy should include not only actions needed to rebuild or upgrade facilities with time frames and cost estimates, but also actions needed to protect the environment and assure the Congress and the public of DOE's safe operation.

Let me briefly describe the types of problems we have identified in the safety and environmental areas, and some of the costs we have identified associated with addressing and resolving these and other problems at DOE's nuclear defense complex. I will begin with an overview of the complex.

DOE'S NUCLEAR DEFENSE COMPLEX

The basic mission, as you know, of DOE's defense complex is to produce nuclear material (e.g. plutonium and tritium) for defense purposes--primarily weapons and naval fuel. The overall complex can be described as costly, diverse, potentially dangerous, and aging. Let me explain.

DOE's funding request for such nuclear defense activities in each of the last 3 years has been over $8 billion. The complex itself represents a public investment of about $100 billion. It includes a wide variety of plants with interrelated purposes, such as nuclear reactors, specialized laboratories, uniquely designed plants for fabricating nuclear material, and nuclear waste facilities. The entire complex will likely grow in the future as new facilities, such as facilities for solidifying high-level radioactive waste, are added to the complex.

DOE's nuclear defense complex, considered in its entirety, is probably one of the more potentially dangerous industrial operations in the world. The operations routinely use and generate large quantities of a wide range of hazardous and radioactive materials. These materials must be handled, transported, and disposed of carefully by workers not only to prevent exposure to themselves but also to prevent these materials from being released into the environment. Because of lethal levels of radiation and high-level heat generation, many of the materials must be handled with special shielded equipment to prevent worker exposure.

DOE operations also involve controlling nuclear reactions and handling highly fissionable nuclear material. The unfortunate Chernobyl accident demonstrates the more dangerous aspects of controlling nuclear reactions and nuclear material. Finally, DOE operations must be protected against the more commonplace industrial dangers, such as fires or other processing accidents.

Along with the inherent dangers of running DOE's complex is the complicating factor that many key aspects of it are aging. In this regard, many of DOE's more hazardous facilities--reactors and reprocessing plants--were built about 30 years ago. Some either have passed or are reaching the end of their designed useful life. For example, the N-reactor in Washington State has passed its originally designed life. So have some high-level waste storage tanks. Many other facilities, such as some buildings at Rocky Flats, Colorado, reactors at Savannah River, South Carolina, and the Fernald plant in Ohio, have safety concerns because of their age.

MAJOR SAFETY ISSUES

GAO's work on safety matters at DOE facilities over the last several years has resulted in several reports that have identified important safety issues. These issues, in view of their importance and scope, raise serious questions about both the safety of individual facilities and DOE operations as a whole. Taken cumulatively they demonstrate the need for independent oversight of DOE operations. Such oversight would provide increased public assurance that DOE operations can be safely operated. I would now like to provide an example of a systematic DOE safety problem and some specific safety examples at a few DOE facilities.

In June 1986,[1] we reported to you on DOE safety analysis reports for eight of DOE's operating facilities. These reports are important documents that DOE uses to show that its facilities are safely designed, constructed, and operated. Our review showed that some safety reviews have not been approved by DOE, some provided little or no comparison with safety design criteria, and different assumptions were used in analyzing serious accidents. We also noted that DOE's safety review process is an internal DOE function carried out primarily by DOE field offices. Because an effective and well-accepted safety review process is the key to demonstrating that a nuclear facility can be safely operated, we made a number of recommendations to ensure that DOE has a credible safety review process.

The situation at the N-reactor is an example of a facility-specific safety issue DOE faces. During the past year, because of the reactor's similarities with Chernobyl, it has come under increasing scrutiny. In our August 1986 report on the N-reactor,[2] we pointed out that the reactor had been operating for 3 years beyond its expected life, and many systems and components were deteriorating, which could become safety problems. In addition, we stated that if the reactor were to operate beyond the year 2000, major renovations would be required. The Roddis panel--an independent group requested by DOE to review the N-reactor--also raised a number of specific safety issues including the need for remote shutdown capability and systems to prevent hydrogen buildup. Two panel members suggested shutting down the reactor while the remaining four called for an accelerated program to upgrade the reactor's safety systems. Subsequently, in January 1987, DOE temporarily shut down the reactor ahead of schedule to upgrade safety systems.

---

[1] Safety Analysis Reviews for DOE's Defense Facilities Can Be Improved (GAO/RCED-86-175; June 1986).

DOE's Rocky Flats plant provides another example. At Rocky Flats, a new building (371) was to be built to lower workers' radiation exposure levels and reduce the danger to the public in the event of an earthquake and/or high winds. Because of technical and design problems, this new building never became fully operational. As a result, DOE is continuing to process plutonium in the old buildings, which the new one was to replace for safety and health reasons. This situation has raised safety concerns about Rocky Flats. DOE is currently studying the possible safety ramifications in the continued use of the Rocky Flats Plant.

---

[2] Comparison of DOE's Hanford N-Reactor with the Chernobyl Reactor (GAO/RCED-86-213BR, August 1986).

In our ongoing work at DOE's production reactors at Savannah River, which is being done at your request, new safety issues have been identified. For example, DOE has recently reduced reactor operating power for safety reasons. We are also concerned that DOE is depending too heavily on visual inspections to detect cracks in reactor vessels. These visual inspections may not clearly identify the extent and magnitude of problems. These concerns and others are to be discussed in detail before this Committee later today by Mr. Keith Fultz, GAO's Associate Director for Nuclear and Electricity Issues. In my view, the discovery of potential safety concerns at Savannah River, when coupled with the uncertainties of the continued operation of the N-reactor, raise questions about the ability of DOE to meet future production requirements for our national defense.

Independent oversight

GAO believes these examples show an important need for increased safety oversight of DOE operations. GAO has had a long history of recommending both internal and external improvements in safety oversight of DOE's defense production activities. In a 1981 report,[3] we pointed out that one of the basic, underlying causes of shortcomings in DOE's safety programs was its structure within DOE. In that report, we argued for a separate office within DOE specifically set up to oversee safety matters within the department and that this office report to the Under Secretary at DOE.

---

[3] Better Oversight Needed For Safety and Health Activities At DOE's Nuclear Facilities (GAO/EMD-81-108; August 1981).

Although DOE originally disagreed with our recommendation, in September 1985, it established an Office of an Assistant Secretary for Environment, Safety, and Health, that reports to the Under Secretary. We believe that DOE's action, in effect, adopted our 1981 recommendation.

Also in the 1981 report and again in a 1986 report, we highlighted the need for outside, independent reviews of safety analysis reports. DOE has been less responsive to this recommendation. In this regard, DOE believes that its own Office of Assistant Secretary for Environment, Safety, and Health provides sufficient independent review. In response to our recommendation, DOE stated

> ". . . an additional level of oversight, over and above that already existing under the guidance of the Assistant Secretary for Environmental, Safety, and Health, would not provide any additional assurances of the safe operations of DOE facilities. . ."

DOE's position on this matter is difficult to understand because DOE, on occasion, does use outside, independent reviews. For example, when faced with safety concerns about the N-reactor because of its design similarity to the Chernobyl reactor, DOE sought outside help. As stated earlier, the Roddis panel reviewed the safety of the N-reactor. More recently, DOE has requested the National Academy of Sciences to review other DOE reactors, including production reactors at Savannah River.

DOE's reluctance to allow for outside independent reviews carries with it important implications. First, there is no outside, independent scrutiny on a continuing basis. This places heavy reliance on DOE's information and views for ensuring safety, which may not be the same as an outside group's. The Roddis panel, demonstrated this difference in their reports, and its views led to accelerating the safety work at the N-reactor. Another implication is possible conflicts between production goals and safety functions. Conflicts can and do occur. The situation at the Fernald plant in Ohio demonstrates this problem. During the 1970's, DOE considered closing this plant. As a result, it did not make capital improvements, and equipment became obsolete. In the early 1980's, DOE's production goals increased, putting a strain on the plant's resources. According to DOE's own documents, Fernald management emphasized production over worker safety and health concerns. Finally, self-regulation provides only a minimum level of public assurance that these facilities can safely operate. This minimum level, I believe is becoming more unacceptable to the public and the Congress as more problems and issues surface in the DOE nuclear defense complex.

In view of the foregoing, I believe outside, independent oversight is critical if DOE wants to provide a high degree of public assurance that its operations are safe and conducted in an environmentally acceptable manner. We are aware that you are proposing legislation that would have the Nuclear Regulatory Commission's Advisory Committee on Reactor Safeguards review and evaluate DOE's nuclear facilities. These hearings you are conducting today, as well as in the next couple weeks, will provide an excellent opportunity for your committee to hear testimony on this proposal and explore with DOE officials the reasons they believe outside oversight is not necessary.

ENVIRONMENTAL ISSUES

Besides safety issues, our reports also have identified important environmental problems needing corrective action. If not corrected, these problems can have a long-lasting effect on the environment and pose a health threat to the general public.

In a September 1986 report,[4] we reported that DOE operations have contaminated groundwater at eight of the nine facilities reviewed. In many cases, the contamination included both hazardous and radioactive material and was at levels hundreds to thousands of times greater than drinking water standards. We also noted that at a few sites some contamination had migrated off-site, into rivers and into drinking water aquifers. We are concerned that the contamination can pose a health threat when it migrates into drinking water sources. Further, we found that the soil was contaminated at most of these facilities in areas not designed to become contaminated. While DOE does have some cleanup projects underway at a few facilities, at most it is studying the problem to better characterize the extent, type, and movement of the contamination.

---

[4] Environmental Issues At DOE's Nuclear Defense Facilities (GAO/RCED-86-192; September 1986).

In a March 1986 report,[5] we addressed DOE's plans to dispose of transuranic waste--a special type of radioactive waste. Basically, DOE set forth a plan to put this waste into a geological repository. We found, however, that DOE planned to send only about 19 percent of its transuranic waste inventory to the repository. DOE was noncommittal regarding the permanent disposition of the remaining 81 percent. Since this waste is buried only a few feet underground, it can pose environmental and/or health problems if it is disturbed or migrates. Remedial actions may be necessary to either remove this waste or better immobilize the waste in place.

In a September 1986 report,[6] we found that four of nine facilities were not in full compliance with the Clean Water Act, and none had final permits for disposing of waste under the Resource Conservation and Recovery Act. As a result, at some facilities DOE is discharging waste into rivers and streams above state limits and is continuing to dispose of waste in a manner that adds to the groundwater contamination. In addition, we found that Hanford[7] had been slow to identify all units that should be regulated under the Resources Conservation and Recovery Act, and it has not identified all potential Comprehensive Environmental Response, Compensation, and Liability Act waste sites that may require corrective actions. As a result, Hanford does not know and cannot ensure the regulatory agencies, that it is appropriately managing or disposing of its radioactive and hazardous waste.

---

[5] DOE's Transuranic Waste Disposal Plan Needs Revision (GAO/RCED-86-90; March 1986).

[6] Environmental Issues at DOE's Nuclear Defense Facilities (GAO/RCED-86-192, September 1986).

[7] Unresolved Issues Concerning Hanford Waste Management Practices (GAO/RCED-87-30; November 1986).

In these past reports, GAO has made recommendations to ensure that DOE operations are carried out in an environmentally acceptable manner. Specific recommendations have included that DOE develop an overall groundwater and soil protection strategy, and provide the Congress a comprehensive report on its plans, milestones, and cost estimates for bringing its facilities into compliance with applicable environmental laws. We have also previously recommended that DOE allow outside independent inspections of the disposal practices used for any waste it self-regulates. DOE has not yet decided on outside, independent inspections of waste disposal because of an ongoing study. We hope one result of this ongoing study will be to allow outside independent inspections of DOE disposal practices as we have previously recommended.

FUTURE COSTS

The cost of dealing with safety issues and environmental problems at DOE facilities will be substantial. In some cases the total cost is speculative because the solutions to problems have not yet come before the Congress. To provide a perspective, some cost estimates are summarized below.

Facility upgrades and modifications are needed at many DOE facilities to enhance safety. Currently, a $50 million safety upgrade program is underway at the N-reactor. Planned safety upgrades for the other production reactors at Savannah River will also cost several million dollars. Safety upgrade programs are also underway at other DOE facilities, such as Fernald in Ohio. Larger expenditures will also be needed in the future. For example, if the N-reactor is to continue operating beyond the year 2000, major renovations costing as much as $1.2 billion will be needed. A new production reactor--which DOE is considering--could also cost billions, even if DOE modifies and finishes construction of the partially completed commercial nuclear reactor owned by the Washington Public Power Supply System. Repairing Building 371 at the Rocky Flats plant could cost about $450 million dollars. If DOE decides to move the entire Rocky Flats plant operation for safety reasons, that move could cost billions of dollars.

Correcting environmental problems will also be costly. At the three facilities we reviewed (Fernald, and Mound in Ohio, and Y-12 in Tennessee) DOE plans to spend over $60 million to bring them into full compliance with the Clean Water Act. To get final permits at the nine facilities we reviewed DOE is changing its disposal operations, at a possible cost of $200 million. The eventual cost could be much higher depending on how site-specific environmental problems are resolved. For example, groundwater cleanup cost can easily amount to hundreds of millions of dollars at a single site. Overall, we believe the eventual cost to bring these DOE facilities into full compliance with environmental laws may be over a billion dollars.

OVERALL STRATEGY

As I said at the outset of my testimony, DOE needs an overall strategic plan that sets forth the projected facility requirements for continued nuclear weapons production; a comprehensive picture of the environmental, safety, and health issues facing DOE; and solutions to resolve them. The plan should provide a comprehensive picture of what DOE's nuclear defense complex will look like in the year 2000 and beyond, and provide a road map of how we get from here to there. The many issues and problems our work has identified that have to be addressed clearly support the need for such a road map. Also, such a strategy would be helpful to maintain continual budgetary oversight. In the longer term billions of dollars will likely be needed to assure that the DOE nuclear defense complex can safely operate; additionally, billions will be needed to bring DOE facilities into compliance with environmental laws.

Some of the broader issues that need to be addressed in this strategic plan are:

-- What are the facility requirements for continued operation of DOE's nuclear defense complex?

-- What is the full scope and extent of the environmental and safety issues facing DOE?

-- What actions will DOE take to ensure that its facilities are operated in a safe manner?

-- To what extent will DOE develop a groundwater and soil protection strategy and clean up contamination at its facilities?

Of course, the strategy should address the resolution of these questions, time frames, and total implementation cost.

Once the strategy is presented to the Congress, it will be useful in making effective legislative and budgetary decisions. Without such a plan, piecemeal solutions to issues and/or problems will occur, as they have in the past. A comprehensive strategy will also place the Congress in a better position to judge the acceptability of the scope and direction of the DOE nuclear defense complex. I hope in these hearings the Committee has the opportunity to explore the need for an overall strategy for the solution of these issues with DOE officials.

In closing, Mr. Chairman, the issues and problems we have identified today are very significant, and the Secretary of Energy needs to take corrective action immediately. Accordingly, we have today forwarded a copy of this testimony to him along with a recommendation that he initiate action on the overall strategy for the DOE nuclear defense program.

That concludes my testimony for today. We would be pleased to respond to any questions you or members of the Committee may have.

GAO REPORTS RELATED TO ENVIRONMENTAL, SAFETY, & HEALTH ASPECTS OF DOE OPERATIONS

NUCLEAR WASTE: Unresolved Issues Concerning Hanford's Waste Management Practices (GAO/RCED-87-30; Nov. 1986)

NUCLEAR ENERGY: Environmental Issues at DOE's Nuclear Defense Facilities (GAO/RCED-86-192; Sept. 1986)

NUCLEAR SAFETY: Comparison of DOE's Hanford N-Reactor With the Chernobyl Reactor (GAO/RCED-86-213BR; Aug. 1986)

NUCLEAR WASTE: Impact of Savannah River Plant's Radioactive Waste Management Practices (GAO/RCED-86-143; July 1986)

NUCLEAR ENERGY: A Compendium of Relevent GAO Products on Regulation, Health, and Safety (GAO/RCED-86-132; June 1986)

NUCLEAR SAFETY: Safety Analysis Reviews for DOE's Defense Facilities Can Be Improved (GAO/RCED-86-175; June 1986)

ENVIRONMENT, SAFETY, & HEALTH: Status of Department of Energy's Implementation of 1985 Initiatives (GAO/RCED-86-68FS; Mar. 1986)

NUCLEAR WASTE: Department of Energy's Transuranic Waste Disposal Plan Needs Revision (GAO/RCED-86-90; Mar. 1986)

ENVIRONMENT, SAFETY, & HEALTH: Environment and Workers Could Be Better Protected at Ohio Defense Plants (GAO/RCED-86-61; Dec. 1985)

ENVIRONMENT, SAFETY & HEALTH: Information on Three Ohio Defense Facilities (GAO/RCED-86-51FS; Nov. 1985)

DOE's Plutonium Facility (GAO/RCED-85-3; Sept. 1985)

Department of Energy Acting To Control Hazardous Waste At Its Savannah River Nuclear Facilities (GAO/RCED-85-23; Nov. 1984)

DOE's Safety and Health Oversight Program At Nuclear Facilities Could Be Strengthened (GAO/RCED-84-50; Nov. 1983)

Decommissioning Retired Nuclear Reactors At Hanford Reservation (GAO/RCED-83-104; Apr. 1983)

Cleaning Up Nuclear Facilities--An Aggressive and Unified Federal Program Is Needed (GAO/EMD-82-40; May 1982)

GAO's Response to DOE on EMD-81-108, "Better Oversight Needed for Safety and Health Activities at DOE's Nuclear Facilities" (EMD-82-36; Jan. 1982)

Congress Should Increase Financial Protection to the Public From Accidents at DOE Nuclear Operations (EMD-81-111; Sept. 1981)

Better Oversight Needed For Safety and Health Activities At DOE's Nuclear Facilities (EMD-81-108; Aug. 1981)

GAO's Analysis of Alleged Health and Safety Violations At The Navy's Power Training Unit At Windsor, Connecticut (EMD-81-19; Nov. 1980)

Department of Energy's Safety and Health Program For Enrichment Plant Workers Is Not Adequately Implemented (EMD-80-78; July 1980)

Decommissioning Hanford Reactor (EMD-79-20; Jan. 1979)

SUBMITTED FOR THE RECORD

Final Report

NEW PRODUCTION REACTOR CONCEPT AND SITE SELECTION ADVISORY PANEL

November 1982

GLENNAN
BLUE-RIBBON REPORT- NPR

November 15, 1982

The Honorable Donald P. Hodel
Secretary
US Department of Energy
Forrestal Building, Room 7A257
Washington, DC 20585

Dear Secretary Hodel:

I have pleasure in enclosing, for your review, the final report of the New Production Reactor (NPR) Concept and Site Selection Advisory Panel (CSSAP) appointed by Deputy Secretary W. Kenneth Davis on July 21, 1982. The "charter" for the Panel, dated July 7, 1982, included a statement of "Objectives and Scope of Activities" which is quoted below.

> "To provide the Department of Energy (DOE) with recommendations on a concept and site selection for an NPR, based on proposed reactor concepts and sites to be furnished to the CSSAP. The major objective of the NPR is the production of tritium and other products to support the maintenance of the Nation's nuclear weapons stockpile. The Panel will prepare a report evaluating and ranking the candidate reactor concepts and sites."

The Panel met as a formal body on three occasions at the Los Alamos National Laboratory--July 27 through 30, August 10 through 12, and September 13 through 15. Additionally, the entire Panel met in Washington, DC on November 1 and 2 to review and complete the enclosed report. Informal meetings involving two to five members of the Panel met on four occasions to clarify or amplify certain members' understanding of particular issues. One such meeting took place at Lawrence Livermore National Laboratory on Monday, August 9, and involved five members of the Panel interested in the SIS process.

The enclosed final report was approved unanimously by the full Panel on November 2 at their meeting in Washington on that date. I think it is worth my recalling that this subject--the choice of a reactor concept and of a site on which it should be located--has been studied on several earlier occasions within the DOE and on at least one recent occasion by a group called together by Dr. Keyworth, the President's Science Advisor, earlier this year. It is suggested, respectfully, that further studies will do little to increase the validity of the recommendations our Panel has made.

We recognize, of course, the proprietary interests of many of the companies and Congressional people whose constituencies may be involved in each of the concepts or sites dealt with by our Panel. I can only say to you that it is my sincere belief that we have dealt with these matters thoughtfully, even-handedly, and in a determined effort to give you recommendations which, in our considered opinion, will best serve the security interests of the United States.

Although six reactor concepts were suggested for our review, we took the liberty of adding a seventh--really a simplification of one we were asked to address. The added "up-front" costs required to provide an energy production capability gave us concern. Providing such a capability would further stress current budget planning and could lower the probability of NPR program approval. The extent to which revenues from the sale of steam will offset such additional costs is a question sensitive to future power demands that would warrant building the generating unit by the USG or by private industry and, of course, to the pricing for electrical power some 15 or more years down the road.

It is a pleasure to commend heartily the services provided to and for the Panel by the good people at Los Alamos, the Albuquerque Operations Office, and members of Mr. Roser's staff. Most of the briefings we heard were provided by members of the Los Alamos National Laboratory staff who, individually and collectively, were very effective in their presentations and most patient in responding to the variety of questions posed by members of the Panel. In particular, I would like to commend James F. Jackson, leader of the Energy Division, who spared no efforts to make certain that the Panel was well served by his associates. Additionally, Dr. Jackson was extremely helpful in the preparation of the final report and the several earlier drafts of the document. Finally, I want to say that the members of the Panel made a team that would be hard to equal in their individual fields of special knowledge and in their willingness to debate the various questions which came up from each member as we worked our way to this final report. Special recognition should be made of the contributions of W. J. Howard who served most effectively as Vice Chairman.

It has been a privilege and a pleasure for each of us to be of service in this endeavor.

Sincerely,

T. Keith Glennan
Chairman, NPR/CSSAP

REPORT OF THE NEW PRODUCTION REACTOR
CONCEPT AND SITE SELECTION ADVISORY PANEL
NOVEMBER 15, 1982

EXECUTIVE SUMMARY

The New Production Reactor Concept and Site Selection Advisory Panel has evaluated the adequacy of future supplies of strategic nuclear materials (tritium and plutonium) and has reviewed seven candidate reactor concepts and four candidate sites for a New Production Reactor (NPR). This report provides the Panel's evaluation and ranking of concepts and sites called for in its charter. The key Panel recommendations are the following:

- An NPR should be constructed to assure an adequate supply of strategic nuclear materials in the 1990's and beyond.
- The NPR must be an efficient tritium producer, but should also be capable of producing plutonium and other reactor products.
- The Zero-Electric-Power Heavy-Water Reactor (ZEPHWR) located at the Savannah River Site is the Panel's recommended NPR concept providing the greatest assurance of meeting production goals.
- A second choice to the ZEPHWR, if the sale of by-product steam is required, is the Low-Temperature Heavy-Water Reactor (LTHWR) at Savannah River or the Replacement N-Reactor (RNR) sited at Hanford. The LTHWR provides better assurance of meeting production goals than the RNR. If tritium production at a site other than Savannah River were considered essential, or if greater emphasis were placed on the future revenue from the sale of by-product steam, the N-Reactor could become the clear second choice, or even the first choice, for the NPR. In fact, the Panel notes that the RNR at Hanford would provide the DOE with the combined program benefits obtained from retaining duality of reactor products production and the sale of by-product steam, together with acceptable assurance of meeting production requirements over the specified design life for NPR.
- The Panel concludes, that for reasons set forth in the body of the report, the other four concepts--Light-Water Reactor (LWR), High-Temperature Gas-Cooled Reactor (HTGR), Liquid-Metal Fast-Breeder Reactor (LMFBR), and Washington Nuclear Project Number 4 (WNP-4)--fail to meet adequately the criteria established by the Panel.

The Panel also concludes that the Savannah River Site should be used for heavy-water reactors and the Hanford Site for all other concepts.

In making the concept and site ranking and evaluations, the Panel has considered numerous criteria. The most important of these were assurance of meeting the production goal for the operation of an NPR. Other important criteria for evaluation of reactor concepts were (1) costs, (2) safety and environmental impacts, (3) sale of by-product steam, (4) use of up-to-date technology, and (5) nonproliferation and public acceptance concerns. In evaluating candidate sites, the Panel was most concerned with (1) providing assured availability of reactor products, (2) ensuring that the site has adequate manpower and facility support for an NPR, and (3) ensuring that the site is suitable in terms of safety, environment, public acceptance, and cost.

STRATEGIC NUCLEAR MATERIALS SUPPLY AND DEMAND

Early in its deliberations, the Panel was given classified information relating to the present status of the Nation's supply of strategic nuclear materials and an estimate of the long-range demand for and supply of such materials. Members of the Panel came to the conclusion that the need for the study they had been asked to undertake was a valid one.

SITE SELECTION

SUMMARY AND CONCLUSIONS

The Panel examined the following four candidate sites specified by DOE for consideration:

--the Savannah River Site (SR) in South Carolina,
--the Hanford Site in Washington,
--the Idaho National Engineering Laboratory (INEL) in Idaho, and
--the Nevada Test Site (NTS) in Nevada.

The selection of the candidate sites was based on the requirement that the NPR be built on a Federal government reservation.

The Panel identified a number of problems with NTS as an NPR site and eliminated NTS from consideration prior to ranking the candidate sites. The principal problems that were identified for NTS were (1) probable conflicts with the US underground nuclear weapons test program, (2) safety questions concerning weapons-test-induced seismicity, (3) the lack of an assured supply of sufficient good-quality water for cooling, and (4) the lack of sufficient support infrastructure to construct and operate a large weapon-materials production reactor along with required fuel-cycle and target-processing facilities.

The remaining three candidate sites were ranked with regard to each of 11 criteria thought to be important for determining the suitability of each for construction of an NPR (see Table I). Except for concerns about concentration of production facilities on one site in the case of Savannah River, both the Hanford and Savannah River sites were found to be satisfactory for the purpose intended. For the LTHWR sited at Savannah River, some salable by-product steam would be produced although the revenue potential, if any, is small. The INEL site was found to be less suitable than Hanford and Savannah River primarily because it lacks experience with many of the facilities and technologies required for a strategic nuclear materials production site.

CRITERIA AND RANKING

The three principal candidate sites, Savannah River, Hanford, and INEL, are ranked with regard to suitability for each of 11 main criteria in Table I. No relative weighting of the importance of these criteria is implied by the order of their listing. The main concerns leading to the relative rankings for each criterion are listed and discussed briefly in the following text.

Two principal assumptions have been made for the purpose of making the rankings. The first is that if the NPR is constructed at any site except Savannah River, a tritium recovery and processing facility will be required to be constructed at that site. Second, the existing facilities at the site chosen for the NPR will be used to support its fuel cycle, with upgrades, additions, and modifications to be made as required.

TABLE I

SITE SELECTION CRITERIA

(1) Water Supply
(2) Support Facilities
(3) On-Site Professional Support and Infrastructure
(4) Construction Labor Availability
(5) By-Product Steam Sales
(6) Waste Disposal
(7) Environment
(8) Transportation
(9) Costs
(10) Public Acceptance
(11) Duality of Sites

1. Water Supply

- All sites have an adequate supply of high-quality water.
- There are potential concerns about contamination of the aquifer at INEL by reinjection of cooling-tower blowdown.

Hanford and Savannah River are ranked essentially equal with regard to water supply. INEL is ranked slightly lower because of potential concerns about contamination of the aquifer.

2. Support Facilities

- Savannah River has sufficient heavy water for a new production reactor and has complete support facilities for a heavy-water reactor fuel cycle.
- Hanford has complete support facilities (except for tritium recovery) for the current N-Reactor fuel cycle.
- INEL has highly enriched fuel-processing and waste-calcination facilities but does not have support facilities for NPR in the plutonium-production mode. Unless the planned expansion of their reprocessing facilities is funded, there will be competition between the naval reactor program and NPR with regard to fuel reprocessing.

Hanford and Savannah River are rated essentially as equal with regard to available support facilities, and with reasonable additions each site could support all reactor concepts. However, Savannah River is more suitable for the heavy-water concepts, whereas Hanford is more suitable for the RNR concept. Hanford and INEL both lack a tritium recovery and processing facility. INEL is ranked significantly lower for all concepts due to a lack of fuel fabrication, plutonium reprocessing, and other production support facilities.

3. On-Site Professional Support and Infrastructure

- Savannah River and Hanford currently support large-scale programs for the production of strategic nuclear materials.
- INEL has no history of special nuclear materials production.

Savannah River has a full complement of on-site professional support capability and is backed up by a single integrated designer, constructor, and operator. Hanford would need to supplement the existing professional complement at the site. INEL is ranked significantly lower on this criterion because they would need a substantial addition to the professional staff.

4. Construction Labor Availability

- A large work force is available very near Hanford or Savannah River.
- Labor stability has been excellent at both Savannah River and INEL. Hanford has experienced construction labor disruption in the past, but indications are that this situation is now satisfactory.
- At INEL, the crafts requirements for an NPR exceed the availability within 50 miles and are a significant fraction of availability within 200 miles for a number of crafts.

Hanford and Savannah River are ranked essentially equal in terms of construction labor availability. INEL is ranked lower because of possible shortages in construction labor with resulting construction delays.

5. By-Product Steam Sales

- By-product steam sales can significantly reduce the unit costs for strategic nuclear materials production, and we assume there will be an adequate market for this steam beginning in the 1990's.
- INEL or Savannah River would need additional high-voltage transmission capability for distribution of NPR power.
- Hanford has a current system of substations and transmission lines as well as a current infrastructure to support the sale of significant quantities of by-product steam from an NPR. The Bonneville Power Administration provides a regional distribution network for wheeling of power from an NPR at Hanford. The precedent for by-product steam sales is established at Hanford.
- The utilities near INEL have volunteered an interest in utilizing the by-product steam for the generation of electricity.

Hanford is ranked the highest of the three sites for sales of by-product steam. INEL and Savannah River are ranked somewhat lower because the additional transmission capability required for electricity distribution makes the purchase of such energy less attractive.

6. Waste Disposal

- Each of the three sites has ongoing programs in waste management and disposal to support an NPR.
- Available on-site support waste-processing facilities will be useful in meeting an early 1990's target operation date for an NPR, but additional facilities will be required.

Construction funding for a waste-solidification facility at Savannah River is expected. There are no plans for a geologic-disposal facility at Savannah River or INEL. DOE has an active program to develop geologic waste disposal in basalt at Hanford. INEL has a facility to convert waste into a calcined product. Funding would be required for a facility to convert this into glass for ultimate disposal.

7. Environment

- Each of the three sites is generally suitable for an NPR from the standpoint of environmental effects.
- The NPR is expected to have low rates of radioactive emissions.

All three sites are ranked essentially equal with regard to environmental criteria.

8. Transportation

- INEL lacks barge access.
- Hanford may avoid off-site shipment of radioactive waste from reprocessing through the possible future establishment of a basalt waste repository.

Hanford and Savannah River are ranked as essentially equal with regard to this criterion. However, if complete waste solidification and a geologic repository are funded at Hanford, it would avoid off-site transportation of radioactive waste, and Hanford would be ranked slightly higher. The lack of barge access to INEL for construction results in a lower ranking for INEL.

9. Costs

- Construction labor rates are lower at Savannah River.
- Hanford and INEL would require a tritium recovery and processing facility for an NPR.
- Hanford may avoid off-site shipment of radioactive wastes.

- Most fuel-cycle facilities for support of an NPR are in place at Savannah River and Hanford (especially for a heavy-water reactor at Savannah River and an RNR at Hanford). New fuel-cycle facilities would be required at INEL.

- Poorer construction labor availability and barge access at INEL may increase costs relative to the other two sites.

- Savannah River has lower construction costs.

10. Public Acceptance

- Each of the three sites enjoys a high degree of local public acceptance.

- Hanford and Savannah River have ongoing production missions that are well accepted, whereas INEL lacks a similar production history.

All three sites are rated as being essentially equivalent in terms of public acceptance of an NPR.

11. Duality of Sites (The Desirability of Having More Than One Site in Operation to Produce Strategic Nuclear Materials)

- All of the current tritium production and most of the current plutonium production takes place at Savannah River.

- N-Reactor at Hanford will cease operation in the early to mid-1990's, at which time all the Nation's strategic nuclear materials would be produced at Savannah River.

- It is important that the US production of strategic nuclear materials not be disrupted by any local site-dependent factor or occurrence.

Hanford and INEL are ranked as most suitable for providing duality of sites in the production complex. Depending on the concept selected, the revenue from sale of by-product steam from the types of reactor that would be built at these sites could exceed the added costs of duality.

SITE CONCLUSIONS

The Panel's conclusions on NPR sites are as follows.

(1) Either the Savannah River Site or the Hanford Site is considered suitable for an NPR.

(2) The Savannah River Site is recommended if a heavy-water reactor is to be built, whereas the Hanford Site is recommended for any of the others.

(3) The Idaho Site was judged to be less suitable because of not having a history of materials production and such additional factors as lack of barge access and concerns over local labor availability and on-site professional support.

(4) The question of site duality was considered by the Panel. Although site duality does offer advantages, the Panel is not aware of any DOE plans to provide this duality in other areas of the weapons-production complex. We do recognize that their very long lead times make the reactor and support facilities a pacing item if such a policy is adopted.

CONCEPT SELECTION

SUMMARY AND CONCLUSIONS

The Panel considered seven candidate reactor concepts for construction of an NPR.

--Low-Temperature Heavy-Water Reactor (LTHWR)
--Replacement N-Reactor (RNR)
--Light-Water Reactor (LWR)
--Liquid-Metal Fast-Breeder Reactor (LMFBR)
--High-Temperature Gas-Cooled Reactor (HTGR)
--Washington Nuclear Project Number 4 (WNP-4)
--Zero-Electric-Power Heavy-Water Reactor (ZEPHWR)

The first six candidates were specified by DOE after an extensive DOE-sponsored screening and evaluation process. The seventh was added to the list by the Panel because it believes the extensive successful experience with Savannah River reactors and the demonstrated capability of the site contractor (duPont) make the ZEPHWR reactor the highest confidence option for satisfying the overriding objective of producing needed strategic materials on a timely basis.

After evaluation of the concepts with regard to a number of important criteria, the Panel recommends the Zero-Electric-Power Heavy-Water Reactor (ZEPHWR) sited at Savannah River as providing the greatest assurance of meeting production goals. A second choice to the ZEPHWR, if the sale of by-product steam is required, is the Low-Temperature Heavy-Water Reactor (LTHWR) at Savannah River or the Replacement N-Reactor (RNR) sited at Hanford. If the sale of by-product steam is required, the LTHWR provides better assurance of meeting production goals than the RNR. If tritium production at a site other than Savannah River were considered essential, or if greater emphasis were placed on the future revenue from the sale of by-product steam, the N-Reactor could become the clear second choice, or even the first choice, for the NPR.

The remaining four concepts (LWR, HTGR, LMFBR, and WNP-4) are downrated for two reasons. The Panel considers that the lack of demonstrated tritium retention and recovery capability of proposed target assemblies makes these concepts' qualifications questionable. Furthermore, these four concepts could raise considerable worldwide concern that the US was developing technology to convert commercial reactors to weapon-materials production. The LWR is ranked fourth because of uncertainties such as fuel and target performance. The HTGR is ranked fifth because the reactor concept has not been fully demonstrated, especially in the size being contemplated, and the technology for reprocessing irradiated fuel and targets is less fully developed. The remaining two concepts, the LMFBR and WNP-4, are found to be unsuitable for a variety of reasons including concerns about product assurance and successfully meeting an early 1990's startup schedule.

CONCEPTS: DESCRIPTIONS, ADVANTAGES, AND DISADVANTAGES

A listing of some of the more pertinent advantages and disadvantages of each of the concepts as perceived by the Panel follows.

1. Zero-Electric-Power Heavy-Water Reactor (ZEPHWR) Sited at Savannah River

The ZEPHWR is a higher-power version of the existing heavy-water-cooled and moderated Savannah River Plant (SRP) production reactors.

Advantages

- Demonstrated constructability, operability, and reliability of heavy-water reactors and supporting systems for producing tritium and plutonium.
- Production-scale operations for fuel and target fabrication, fuel reprocessing, and tritium and plutonium separation in place and operational.
- Low temperature and pressure operation.
- Simplicity of design and operation (not complicated by commitments to produce and sell by-product steam).
- Complete life-cycle experience.
- Production-scale waste solidification is planned, and funding is expected.
- duPont is a single integrated designer, constructor, and operator with an outstanding record of competence, experience, depth, and reliability.

Disadvantages

- Scale-up on size of reactor and number of target assemblies required. This design effort is in the conceptual stage.
- New design of emergency-core-cooling system, tritium removal, and containment required.
- Highest annual operating costs of the concepts. (No sale of by-product steam to offset production costs.)
- Has not undergone updated safety review based on strict compliance with current safety standards.

- Concentration of production facilities at a single site.
- Interactions with existing operating reactors have not been fully investigated.

2. Low-Temperature Heavy-Water Reactor (LTHWR) Sited at Savannah River

The LTHWR is a vertical-pressure-tube reactor, cooled and moderated by heavy water. It is similar in concept to the existing Savannah River Plant (SRP) production reactors, except that pressure tubes will be added to allow for the higher temperatures required for power generation.

As in the other by-product steam-producing concepts, the Panel assumes that either an investor- or government-owned electric power producer would be willing to purchase the by-product steam from the NPR at a price approaching its avoided costs and to provide the turbine-generator and interconnection facilities. The smaller amount of by-product steam available from LTHWR limits the potential revenue from steam sales for this concept.

Advantages

- A small extrapolation from present Savannah River reactors with demonstrated constructability, operability, and reliability of reactor and supporting systems for producing tritium and plutonium.
- Production-scale operations for fuel and target fabrication, fuel reprocessing, and tritium and plutonium separation in place and operational.
- Low temperature and pressure operation.
- Production-scale waste solidification planned, and funding is expected.
- duPont is a single integrated designer, constructor, and operator with an outstanding record of competence, experience, depth, and reliability.

Disadvantages

- o Scale-up on size of reactor and number of target assemblies required. Design in conceptual stage.
- o As in subsequent concepts, design complicated by commitment to produce and sell by-product steam. (Addition of pressure-tube technology for the LTHWR.)
- o New design of emergency-core-cooling system, tritium removal, and containment required.
- o Lowest ranking of the power producers in life-cycle cost benefits.
- o Has not undergone updated safety review based on strict compliance with current safety standards.
- o Concentration of production facilities at a single site.
- o Interaction with existing operating reactors has not been fully investigated.

3. Replacement N-Reactor (RNR) Sited at Hanford

The RNR is a graphite-moderated water-cooled pressure-tube reactor that builds upon the experience of the existing N-Reactor.

Advantages

- o Small extrapolation from N-Reactor technology with some upgrading for graphite stability, refueling, and steam generators.
- o Demonstrated base of reliability, constructability, and operability for plutonium production.
- o Demonstrated coproduction of tritium and plutonium.
- o A second-generation production reactor, since there is no scale-up in power level.
- o Production-scale operation for fuel fabrication in place. Proven fuel components for plutonium production.
- o Existing Purex fuel reprocessing for plutonium production is being reactivated.

- Existing operating contractor with excellent record and complete life-cycle experience with the N-Reactor and its fuel cycle.
- On-site capability in reactor design, reprocessing technology, and waste management.
- Possible future on-site geologic waste repository in basalt.
- Revenue from sale of by-product steam could more than offset the difference in costs compared with heavy-water reactor options.

Disadvantages

- Redesign of enriched fuel and tritium targets required. Slightly higher temperature than in the present N-Reactor may affect tritium containment.
- New design of refueling, steam generators, graphite, and containment required.
- Additional waste volume from redesigned fuel.
- New facilities for processing tritium targets required.
- New facilities for dissolving new fuel are required.
- Has not undergone updated safety review based on strict compliance with current safety standards.
- Because of the present infrastructure of many different organizations, requires an integrating contractor assignment for NPR similar to the duPont role for heavy-water reactors.

4. Light-Water Reactor (LWR)

The LWR is based on current commercial pressurized-light-water-reactor (PWR) technology, specifically the Westinghouse four-loop PWR. With the exception of core and targets, the LWR incorporates components and systems in the reactor and balance of plant identical to those in currently operating PWRs.

Advantages

- Design based on Westinghouse advanced pressurized-water-reactor technology except for fuel and targets. It represents a mature industry option which has design, construction, and operating expertise available. The basic LWR concept has undergone numerous safety reviews, but the redesign will need new safety reviews.
- Because design is based on current PWR technology, confidence can be placed in cost and schedule estimates. Except for the core and targets, designs are well advanced.
- Revenue from sale of by-product steam could more than offset the difference in costs compared with heavy-water reactor options.
- The LWR has been a reliable and economic producer of steam for electricity.

Disadvantages

- Potential worldwide concern over use of commercial nuclear technology to produce weapons material.
- Prompt negative temperature coefficient of reactivity of low-enrichment PWRs is greatly reduced.
- Proposed fuel will require some fabrication R&D.
- Startup date contingent on sequential steps of competitive bidding for a reactor design and selection of an integrating contractor.
- Insufficient evidence of tritium retention in target.
- If current target design is used, its low melting temperature increases probability of target redistribution in core-melt accident in this reactor type. If higher temperature target is used, performance of the escape barrier must still be demonstrated.
- New facilities required at Hanford for dissolving fuels.

- Risk of production being disrupted by response to public pressure to address issues raised in connection with commercial LWRs.
- Has not undergone a safety review with the core and targets required for tritium production.

5. High-Temperature Gas-Cooled Reactor (HTGR)

The HTGR is a helium-cooled graphite-moderated reactor that is based directly on designs proposed for commercial HTGR power plants.

Advantages

- Revenue from sale of by-product steam could more than offset the difference in costs compared with heavy-water reactor options.
- Driver fuel developed and demonstrated.
- Production-scale operation for fuel fabrication.
- General Atomic has made good progress in overcoming problem of tritium retention in high-temperature targets.
- Rapid heat transfer to core graphite provides slow core heating during transients.
- If located at Hanford, would benefit from partial use of Purex facility and from possible high-level waste geologic repository.
- If located at Idaho, would benefit from Idaho experience to be gained in reprocessing Rover graphite fuel and would benefit from partial use of reprocessing facility.
- NRC has approved highly enriched operation at Fort St. Vrain, but the redesign will require a complete safety review.

Disadvantages

- The NPR would be a significant scale-up and redesign from existing HTGR experience.
- There is not sufficient US construction and operating experience to provide a satisfactory basis for assuring constructability, operability, and reliability of production.
- Experience at Fort St. Vrain does not provide assurance that such a reactor can be built and operated reliably to meet production goals.

- Technology for fuel and target reprocessing has not been fully developed.
- Large volume of radioactive waste whether or not spent fuel is reprocessed for uranium recovery.
- New facilities for fuel and target reprocessing would be required.
- High front-end costs.
- Has not undergone safety review with targets for tritium production.

6. Liquid-Metal Fast-Breeder Reactor (LMFBR)

The LMFBR is a liquid-sodium-cooled pool-type reactor in which the entire primary system is contained in the reactor vessel.

Advantages

- High neutronic and thermal efficiency.
- Advances LMFBR technology for which there is a national commitment.
- Revenue from sale of by-product steam could more than offset the difference in costs compared with heavy-water reactor options.
- A large volume of subcooled sodium can provide substantial protection against evaporation of core coolant in an accident.
- Large laboratory and industrial infrastructure available to support development. Concept utilized in US at EBR II and FFTF.

Disadvantages

- Target technology not proven.
- Capital costs highest of all reactor concepts.
- Sodium-coolant technology less well demonstrated than water.
- Poor utilization of fast-neutron spectrum.

- Significant scale-up and redesign from existing LMFBR experience.
- Very unlikely to meet production goals by early 1990's.
- Major extrapolation of existing US LMFBR technology.
- Has not undergone safety review with new fuel and targets.

7. Washington Nuclear Project Number 4 (WNP-4)

WNP-4 is a Babcock and Wilcox pressurized-water-reactor (PWR) power plant located on the DOE Hanford Reservation. Although 24% complete with essentially all of the nuclear steam supply system designed and procured, the plant has been terminated by the Washington Public Power Supply System (WPPSS). Large components such as the reactor vessel, vessel head, core barrel, and steam generators are on site. The balance of the plant is virtually completely engineered, and construction is well under way on major structures such as the containment building, general-services building, turbine-generator building, and cooling towers. NRC licensing is continuing based on the twin WNP-1 unit. A total of $804 million has been spent to date.

Advantages

- Design based on established commercial (Babcock and Wilcox) pressurized-water-reactor technology except for fuel, targets, and any special safety systems that might be required.
- Partially completed plant (about 25% of construction and 88% of procurement).
- Revenue from sale of by-product steam could more than offset the difference in costs compared with heavy-water reactor options.
- Potential schedule and cost advantages.
- Located at one of the desirable production sites.

Disadvantages

- Less-than-goal production capability.
- Public concern stemming from use of a commercial plant for weapon-materials production.
- Uncertainty in legal and contractual issues could delay construction.
- Specialized production-type fuel would require a reengineered safety system.
- Storage of components already on site introduces concerns regarding quality control.
- Prompt negative temperature coefficient of reactivity of low-enrichment PWRs is greatly reduced.
- High waste volume from fuel.
- Production may be interfered with because of public pressure to address issues raised in connection with commercial LWRs.
- Has not undergone a safety review with the new core and targets required for tritium production.

CONCEPT EVALUATION CRITERIA

TABLE II

CRITERIA FOR REACTOR-CONCEPT EVALUATION

- Product Assurance Once Operational
  - --Status of target technology
  - --System operability, reliability, and maintainability
  - --System flexibility
  - --Level of production
  - --Amount of technological extrapolation
- Confidence in Meeting Early 1990's Startup Date
  - --Current design status
  - --Recent design, engineering, and construction experience
  - --Infrastructure to support design and construction
  - --Development status of major components
  - --Full-scale operation/demonstration
  - --Research and development requirements
- Initial Up-Front Costs
  - --Capital costs
  - --R&D costs
- Levelized Product Costs
  - --Confidence in capital and operating costs
  - --By-product steam sales
  - --Level of production
- Safety and Environmental Considerations
  - --Radiation exposures
  - --Effluent discharges
  - --Reactor safety
- Strategic/Institutional Issues
  - --Duality of reactor concepts and sites
  - --By-product steam production
  - --Up-to-date technology
  - --Advancement of nuclear technology
  - --Nonproliferation issues
  - --Public acceptance

The criteria used in evaluating the candidate-reactor concepts for an NPR are listed in the foregoing Table II and described briefly in this subsection. The criteria of product assurance and operation in the early 1990's are of principal importance. However, strategic and institutional issues are also given significant weight in making the concept recommendations.

1. Product Assurance Once Operational

Once the NPR is operational, it is essential that it produce goal quantities of tritium reliably to supply the US defense needs. The absolute level of reliable production for each concept is therefore of primary importance. A high level of production helps assure that tritium demand will be met in spite of unanticipated shutdowns or operational difficulties. Assurance or demonstration of operability, reliability, and maintainability provides additional confidence that production goals will be met.

For tritium production, it is important that a suitable lithium target be available in the near future, a target that produces sufficient tritium, retains the tritium while in the reactor, and allows the tritium to be totally recovered in processing. While tritium production is the primary mission for an NPR, it is important that an NPR also be flexible by being capable of plutonium production or coproduction if necessary.

2. Confidence in Meeting Early 1990's Startup Date

The Panel feels that it is important that an NPR be operational by the early 1990's. The confidence that this schedule can be met is strongly affected by a number of factors. These factors are generally related to applicable past and recent experience, program R&D needs, and the current design status of the candidate-reactor concepts.

Recent design, engineering, and construction experience with a reactor concept may lead to a more rapid construction schedule, as may the availability of a large organizational infrastructure to support construction of the concept reactor. Prior full-scale operation of a concept reactor for an extended period provides added confidence that significant problem areas will have been identified prior to construction. The status of the reactor design and the status of component development each affect the confidence in any projected construction schedule.

In addition to confidence in meeting the early 1990's start-up date, the above factors also affect other criteria. For example, cost contingencies must be increased for those concepts that are in only very preliminary design stages. Concepts lacking recent design, engineering, and construction experience may not conform to current standards nor incorporate the most recent technology.

3. Up-Front Costs

The up-front costs for an NPR are the reactor capital costs and the incremental R&D costs needed to construct a concept reactor. The base program R&D cost has not been considered in this evaluation of candidate-reactor concepts. In general, the capital costs are much higher than the required incremental R&D costs.

Reactor concepts having particularly low capital costs have less budgetary impact, a positive attribute for achieving public and Congressional acceptance. Very high capital-cost concepts may prove to be unacceptable, particularly if the NPR program becomes controversial.

4. Levelized Product Costs

The levelized cost reflects all costs net of revenues over the life of the reactor and adjusted for the time-value of money. A major contributor to the levelized tritium costs are the capital costs, which are considered explicitly as a separate criterion due to their immediate impact on the government budget process. A contributor to estimated capital costs are contingencies arising from the uncertainties due to extrapolation of designs from existing experience and concerns related to construction difficulties.

In evaluating the NPR reactor concepts, the absolute level of production is important in that low production levels tend to result in higher relative levelized costs (although this effect can be reduced by lower capital costs). A major factor in the NPR levelized product costs for by-product steam-producing NPR concepts is the revenue stream arising from sale of by-product steam. Revenue from sale of by-product steam could more than offset the difference in costs compared with heavy-water reactor options.

5. Safety and Environmental Considerations

It is important that an NPR operate in a safe and environmentally responsible manner. The NPR must meet safety and environmental standards comparable to those for commercial nuclear reactors. Radiation exposures and effluent discharges are to be kept as low as reasonably achievable. Concepts having inherent safety features or proven redundant engineered safety features have advantages under this criterion over those lacking such features.

6. Strategic and Institutional Issues

These issues comprise many different concerns that may or may not be interdependent. Many of them reflect on the acceptability of an NPR concept. The five principal strategic and institutional issues are described below.

a. Duality of Production Concept. Because a generic problem can develop with any reactor technology, some diversity of reactor design could be an advantage in the production complex. Without duality of concept, a major generic or regional problem could threaten to shut down the entire production complex.

b. By-Product Steam Production. Use of by-product energy that would otherwise be dumped will contribute to national energy resources, minimize thermal discharges, and provide revenue to offset costs. The ability to sell by-product steam for electric power generation may also allow retention of production capability during periods of reduced tritium or plutonium demand. (This was the case with the N-Reactor.)

c. Up-to-Date Technology. In building an NPR, it seems appropriate to take advantage of the technology development that has occurred over the past few decades, much of it at taxpayers' expense. In addition, since an NPR will be used well into the next century, the risk of technical obsolescence should be minimized.

d. Advancement of Nuclear Technology. Depending on the concept selected, the development and construction of an NPR may make useful contributions to the advancement of nuclear technology and nuclear safety.

e. Nonproliferation Issues. A proposal to use commercial nuclear technologies to produce weapon materials may raise grave concerns about nonproliferation.

CONCEPT CONCLUSIONS

The Panel's conclusions on NPR concepts are summarized below:

- The Zero-Electric-Power Heavy-Water Reactor (ZEPHWR) located at the Savannah River Site is the Panel's recommended NPR concept providing the greatest assurance of meeting production goals.
- A second choice to the ZEPHWR, if sale of by-product steam is required, is the Low-Temperature Heavy-Water Reactor (LTHWR) at Savannah River or the Replacement N-Reactor (RNR) at Hanford. The LTHWR provides better assurance of meeting production goals than the RNR. If tritium production at a site other than Savannah River were considered essential, or if greater emphasis were placed on the future income from the sale of by-product steam, the N-Reactor would become the clear second choice, or even the first choice, for the NPR. In fact, the Panel notes that the RNR at Hanford would provide the DOE the combined program benefits obtained from retaining duality of reactor products production and the sale of by-product steam, together with acceptable assurance of meeting production requirements over the specified design life for NPR.

- The LWR is ranked fourth. The LWR and the following three concepts all suffer from proliferation and tritium-target concerns.
- The HTGR is ranked fifth because the reactor concept has not been fully demonstrated, especially in the size being contemplated, and the technology for reprocessing irradiated fuel and targets is less fully developed.
- The LMFBR is ranked sixth, in part because its development is less advanced than the other concepts.
- The WNP-4 reactor is ranked last, primarily because of retrofitting problems and the potential for adverse public perception of converting a plant designed for commercial production of electricity to production of weapons material.

The ZEPHWR sited at Savannah River and designed, constructed, and operated under duPont supervision and management is the concept most likely to provide the required amount of tritium by the early 1990's. The design of this system represents the least departure from proven technology, and the availability of a contractor of such proven competence and experience as duPont provides the greatest assurance that production goals will be met at predictable costs.

If production of electricity along with tritium is essential, the Low-Temperature Heavy-Water Reactor (LTHWR) sited at Savannah River and designed, constructed, and operated under duPont supervision and management is the concept regarded as most likely to meet production goals by the early 1990's primarily because of the availability of duPont as the integrating contractor for NPR.

If production of tritium at a site other than Savannah River or an amount of by-product steam greater than available from a LTHWR is considered essential, the Replacement N-Reactor (RNR) sited at Hanford is the concept considered most likely to meet production goals by the early 1990's. If greater emphasis than the Panel's were placed on the future income from the sale of by-product steam, or if tritium production at a site other than Savannah River is deemed essential, the RNR could become a clear second choice, or even first choice for the NPR. The reactor design is a substantial improvement over the present N-Reactor, and like the heavy-water reactors, is a minimal departure from proven technology. The fuel and target designs are different but have been demonstrated by operation on a respectable scale. Contractors are available at Hanford with experience in running this type of reactor and carrying out the fuel-cycle operations it requires.

An LWR used as a tritium producer would require some development of cermet fuels and considerable target exploration to choose a proven target. Use of LWR technology for US weapon production could be interpreted as leading the way to weapon-material application of power reactors around the world--a proliferation consideration of major implications. There is also a risk of production being disrupted by response to public pressure to address issues raised in connection with commercial LWRs.

Any HTGR installation would require considerable scale-up to reach NPR production quantities, and US experience at Fort St. Vrain fails to provide assurance that the US can build and operate an HTGR-NPR reliably enough to meet production goals. High front-end costs, considerable remaining technology development, and schedule concerns for an NPR lead to this ranking for the HTGR as a production reactor.

Neither the LMFBR nor WNP-4 provide confidence that tritium production requirements could be met by the early 1990's. The LMFBR's high capital costs, substantial target uncertainties, and large required plutonium inventory results in its low position in the ranking. The inability to meet goal-production quantities and the potential for numerous institutional problems leads to a recommendation against the WNP-4 concept.

The Panel considered the advantages that could accrue from selling by-product steam to an electrical power system. These advantages could include protection against inflation, the offsetting of operating costs, and justification for continuing facility operation during periods of low materials demand. The Panel recognizes that the magnitude of power-generating revenues is uncertain and will be influenced by demand and kWh-pricing variations and production reactor operation.

The likelihood of a reactor-products-demand-slump seems remote. In the 1960's the N-Reactor, but for its role as a power generator might have been closed. Power generation can have negative aspects beyond the higher up-front costs. These include possible licensing exposures, added interface and infrastructure requirements, and recognition of the US sentiment to separate weapon-materials production from commercial power.

In general, the Panel felt that the available cost and schedule predictions are also uncertain, especially with respect to absolute and even to relative costs. This led the Panel to apply its own judgment in the area of expected costs.

Members of the Panel would like to call to the attention of those responsible for these matters the fact that, if one NPR is on stream in the early '90s, the DOE will have provided, in fact, only for the replacement of a portion of the production capacity of the existing Savannah River production reactors, all of which will then be approaching 40 years in service. Since the principal product expected to be produced in the NPR is a relatively short-lived material, it appears to us that the exercise we have just completed should be repeated at intervals to insure a continuing availability of modern production facilities so long as these materials are forecast to be needed. A continuing moderate level of effort in R&D will be justified to insure that production reactors authorized for construction in later years will continue to be as up-to-date as then current design and new technology will permit.

(The report in its classified form was signed by the Committee on November 15, 1982. The panel consisted of the following members:

Frank Baranowski
Wallace B. Behnke
Manson Benedict
Robert E. Hollingsworth
Thomas H. Pigford
William J. Howard, Vice Chairman
T. Keith Glennan, Chairman)

INDEPENDENT CONSULTANTS REPORTS

N-REACTOR SAFETY

Louis H. Roddis, Jr.
Miles C. Leverett
Harold W. Lewis
E.P. Wilkinson
Gerald F. Tape
Thomas H. Pigford

OCTOBER 1986

DOE F 1325.8
(12-84)

United States Government Department of Energy

memorandum

DATE: December 10, 1986

REPLY TO
ATTN OF: EH-1

SUBJECT: Response to Recommendations from the Individual Consultant Reviews of N Reactor

TO: The Under Secretary

Background:

As a result of the reactor accident at Chernobyl, Secretary Herrington requested separate reviews of N Reactor at Hanford by six outside consultants (Messrs., Roddis, Wilkinson, Tape, Leverett, Lewis, and Pigford). The consultants' efforts were in addition to the three safety reviews of N Reactor performed by my office at the Secretary's request, and which were also in keeping with the Secretary's 1985 initiatives in environment, safety and health to provide a comprehensive basis for any necessary action to enhance safety excellence at N Reactor.

The specific charge to these consultants was to review the facts and findings surrounding the Chernobyl accident, to examine N Reactor safety in light of this information to assure that all key technical questions and safety issues have been considered, and to examine the findings stemming from the Department's safety reviews of the N Reactor to assure that all relevant facts and findings from the accident have been addressed by the review teams. On May 23, 1986, you further briefed the consultants on the Department's objectives. Each consultant was asked to and did submit an individual report.

On October 6, 1986, you asked me, as the Assistant Secretary for Environment, Safety and Health (EH), to convene a group, including Headquarters and Operations Office staff (RL and Idaho), to review and analyze the consultants' reports and evaluate the consultants' findings relative to the three safety reviews conducted by EH since Chernobyl: the Design Review, Technical Safety Appraisal, and the Special Safety Review of N Reactor.

The review of the consultants' reports has been completed. A summary analysis is provided below.

1. Chernobyl:

   The consultants conclude that a Chernobyl-type accident at N Reactor is either "impossible" or "not plausible" given the design differences of the reactors and additional operational safeguards that exist for N Reactor. However, several consultants point out that this accident affords the opportunity to examine the Chernobyl accident for lessons learned and focus on possible enhancement of N Reactor safety.

2. Completeness of DOE reviews:

Each of the consultants concluded that relevant technical questions and safety issues have been considered by the N Reactor contractor, United Nuclear Industries, Inc., and by the Department's EH review teams. They support the recommendations made in the three EH reviews and emphasize the need for effective implementation of required actions. Several consultants identified areas that, in their view, deserve particular emphasis in the implementation plan. These included concerns that assumptions had been made in the safety analyses that are not conservative enough regarding the mixing of hydrogen in confinement, the performance of the fog sprays and a failure to consider the fate of contaminated water released in an accident.

Position: An implementation plan, the "Safety Enhancement Program Plan" (SEP) has been developed by the contractor, United Nuclear Corporation (UNC), in order to implement the recommendations made by the EH teams in these safety reviews.

EH staff reviewed a draft of this document and concluded that the proposed program for action should be accelerated (see Attachment 1). Accordingly, the implementation plan is being modified to accomplish this objective. The modifications will also address the additional technical concerns raised by the consultants' reports.

3. Severe Accident Mitigation:

Even though the consultants concluded that a Chernobyl-like accident could not occur, they recommended that increased attention be given to analysis of such events. To that end, even through the probability is low, they suggested that additional measures for prevention and mitigation of other types of severe reactor accidents be undertaken, with special attention to hydrogen mitigation and control.

Position: An accelerated program to address low probability, high consequence events is being performed by Los Alamos National Laboratory. The draft report on severe accident risks is now scheduled for completion in March 1987. A program is now underway to install improved hydrogen detection and mitigation equipment.

4. Comparability:

Substantial upgrades have been made to N Reactor since it began operation. In spite of these changes, the consultants expressed concern about the differences between N Reactor design and current requirements for commercial power reactor safety design and operation. Some concluded that improvements were necessary if the N Reactor was to be brought to a level of safety comparable to commercial reactors.

Position: A number of reasons might be advanced for these differences, some historical, some relating to the original, unique design of the facility. The Department does not require strict comparability with safety practices for light water reactors in the U.S. or abroad.

The reason for this is that the Department must give consideration to the special mission for the N Reactor. The N Reactor has demonstrated a long period of accident free operation. There have been many safety upgrades since the reactor was first brought into operation.

The EH reviews to date have not revealed any areas in which there exists an unacceptable level of safety. A properly crafted Safety Enhancement Program Plan will further improve the safety of N Reactor operations, but it should be recognized that there are limited gains possible from upgrades that might be put in place during the remaining life of the reactor.

5. Specific recommendations for changes to the facility:

The consultants find that the safety of N Reactor can be improved by additional administrative, operational, and technical changes.

These improvements include:

- Additional operator training to improve ability to respond to unusual and unanticipated events
- Remote reactor shutdown capability
- Utilization of the simulator in training for a severe accident
- Additional redundancy and backup for the ECCS
- Increased surveillance of reactor components and systems
- Testing of confinement and other safety-related system hardware under accident environment conditions
- Installation of hydrogen mitigation system
- Preventing uncontrolled discharges of contaminated water outside of confinement in the event of an accident

Position: We agree with these recommendations and they are or will be addressed in the modified Safety Enhancement Plan. (Many of them were previously raised and were the subject of recommended actions in the three EH safety reviews.) Some recommendations call for immediate actions (e.g. to immediately proceed to install a hydrogen mitigation system) while the program office proposal is to complete ongoing analyses before deciding on the kinds and timing of upgrades to be made. A draft Probabilistic Risk Assessment (PRA) will be available by March 1987. The timing and scope of some of the above mentioned items will be reexamined when the PRA is available, while some actions can be taken immediately.

6. Discharges to the Soil:

Several consultants stated that direct discharges into a soil column of both primary coolant during routine circumstances and radioactive liquids during an accident should be stopped as unacceptable practices.

Position: Routine discharge of coolant is not an acceptable practice. RL is now exploring interim measures that could be put in place in this fiscal year to substantially change this practice. In terms of the accident case, RL is currently addressing alternatives in a conceptual design review. EH is committed to encouraging and supporting activities that will result in the elimination of discharges to soil columns in an expeditious manner. RL and EH staff discussions are now occurring consistent with this goal.

7. ACRS Reviews:

Several of the consultants recommended that greater use be made of the Advisory Committee on Reactor Safeguards.

Position: We agree that an ad hoc use of the ACRS is appropriate. The ACRS was last used in 1978 to review the Fast Flux Test Reactor. The mechanism for employing such reviews still exists and we recommend you consider this recommendation of the consultants, taking into account the Department's previous, successful ad hoc use of the ACRS and the existing independent oversight function vested in EH, to assure that there would be no duplication of effort.

8. INPO: The consultants suggested that N Reactor make increased use of the Institute for Nuclear Power Operations, and that the Department consider broader use of that type of review for other facility operations.

Position: United Nuclear has already re-examined its INPO participation and will seek to increase its involvement. Other DOE facilities are not eligible for membership in INPO under the latter's current charter. We recommend, however, that you should consider a review of this recommendation in light of the on-going NAS/NAE review of DOE's Class A reactors. In the meantime, UNC should increase its interaction with INPO for N Reactor.

9. Compliance with Dose Guidelines for Design Basis Accident:

One consultant noted that in 1966, the ACRS found that 10 CFR Part 100 guidelines were not met for the limiting design basis accident; the consultant concluded that this was still the case.

Position: The N Reactor Updated Safety Analysis Report (1978) presents analyses which conclude that design basis accident consequences are within guideline values. The contractor should prepare a specific response to the consultant's statement, taking into account the most recent calculations of accident consequences.

10. Other Findings/Recommendations:

In addition to their positions on the key areas above, the consultants made other findings and recommendations concerning N Reactor safety. These recommendations involved additional analyses, improvements, or considerations which would serve to improve the safety of N Reactor operations:

- o The safety analysis of design basis accidents be updated.
- o Increased surveillance of the graphite and pressure tubes to assure that safety limits are not exceeded as the N Reactor nears the end of its useful life.
- o Clarify Departmental lines of authority and responsibility for safety in DOE's operation.
- o Recognize and combat organizational complacency in the operation and maintenance of N Reactor.

This memorandum cannot address all of the consultants individual findings and recommendations. However, all will be addressed in the modified implementation plan.

11. Consultants' Conclusions on Continued Operation:

Four of the six consultants find the continued operation of N Reactor acceptable, if two conditions are met. The first condition is that the design and operational improvements recommended by both the EH review teams and the consultants' reports be implemented. The second condition is that the analyses of hydrogen generation and mitigation and confinement performance be completed and indicate an acceptable level of safety.

Two consultants go further and recommend immediate and near-term shutdown, respectively, unless national security considerations dictate otherwise. Their recommendations rest on their view that the N reactor poses risks exceeding those of commercial reactors.

Position: As indicated, in response to the three EH reviews, the GAO report, and preliminary findings provided by the consultants during their review, UNC has prepared the Safety Enhancement Program Plan that will implement the EH recommended actions and will, when modified, implement the consultants' technical recommendations. In addition to the formal commitments for comprehensive safety analyses, and facility design and operational improvements, the operating contractor has already initiated activities to provide preliminary analyses of key areas of concern, e.g., hydrogen generation and mitigation.

A number of actions included in the Safety Enhancement Program have already been completed. Some of the more important efforts include:

- o A re-analysis of hydrogen concentrations following severe accidents using new codes. Preliminary calculations using latest available data show that the confinement system can accommodate the effects of the most severe design bases accident.
- o A study of local hydrogen burning which shows that it is not a serious problem (an issue raised by one of the consultants).

- The engineering phase was completed for supplemental emergency core cooling supply.
- The Emergency Response Facility was relocated to provide better emergency preparedness.
- The first major step towards an enhanced confinement performance was completed (an analysis of the possible weak links in confinement vent valves).

The EH reviews of all activities at Hanford, including the reviews by the six consultants, have led us to conclude that a major effort should be undertaken to correct identified deficiencies as soon as reasonably possible. To this end the following measures are recommended in addition to those already underway:

(1) Advise the program office that high priority tasks described by the Safety Enhancement Program Plan must be accomplished as quickly as possible, such that early decisions can be reached on key safety issues, e.g., hydrogen mitigation, use of soil columns for liquid discharges, and confinement effectiveness.

(2) Bring the reactor operation to a stand down condition. Devote the time and available staff resources to "clear the decks" of planned safety enhancements which can be accomplished in the near term. A program, as approved by you, should be put in place before operation resumes. This program should include a specific timetable for installing additional equipment and for implementing improved procedures. This will permit an accelerated pace for the Safety Enhancement Program.

(3) The Safety Enhancement Program Plan should be revised to reflect the program approved by you, and should include a specific timetable for the installation of equipment and implementation of new procedures.

(4) The entity awarded the consolidated operating contract at Hanford should be asked, as a first priority, to perform a thorough analysis of the program for enhancing the safety of N Reactor and to endorse and/or propose further changes to the program.

(5) The oversight function provided by the Richland Operations Office should be strengthened to assure that adequate resources are brought to bear on assuring effective contractor action. To this end a dedicated capability should be established within the safety overview function of the Richland Operations Office to specifically review and monitor the implementation of the N Reactor Safety Enhancement Program.

I believe these recommended steps will provide increased confidence that N Reactor can continue to be operated safely. However, it should be emphasized that under this proposed course of action continued operations would be based on having certain key information in hand:

- o Draft probabilistic risk assessment - Initial results will be provided in late March 1987. The results could identify inadequacies in design.
- o National Academy of Sciences review - Their initial findings and recommendations are expected in March and will need to be considered in the context of the aggressive action plan proposed above.
- o Graphite growth - The results of the most recent graphite, pressure tube and safety system surveillance programs will have been analyzed providing an improved definition of when graphite growth and other aging effects will begin to impact safe operation.

Since several key analyses and reviews addressing reactor safety will be completed in the early spring, a status report should be prepared for you (through DP and requiring concurrence by EH) by April 15, 1987. That report should summarize the progress towards meeting the milestones in the approved Safety Enhancement Program and should address the three areas identified above. (PRA results, NAS review and graphite growth.) The objective of the report is to determine whether the results are consistent with continued operation at an acceptable level of safety.

These steps might not all have been suggested under different circumstances. Given the efforts to improve operating safety at PUREX and PFP, and recognizing the need to assure that all ES&H issues at N Reactor are directly and fully addressed, an abundance of caution is appropriate. A clear, forceful approach is needed that will resolve management and technical issues that have been raised since Chernobyl.

To this end I would recommend that you implement the recommendations for further actions that are outlined above.

Mary Walker

Mary L. Walker
Assistant Secretary
Environment, Safety and Health

Attachment

ATTACHMENT 1

UNC Milestones for Safety Enhancement and Areas Where Further Acceleration Should be Considered

EH Rec. 1/	Should Accelerate	Consult. Rec. 2/	
			Scheduled in the SEP for Completion by January 1, 1987
41			Analyze graphite cooling system water impinging on embrittled pressure tube
107			Evaluate exhaust systems to assure compliance with American Conference of Governmental Industrial Hygienists Manual
127			Revise Safety and Environmental Engineering Instructions to clarify when procedures can be reused
128			Enforce time limits for Temporary Plant Modifications
			Scheduled in the SEP for Completion by April 1, 1987
67	X		Develop means to prevent flammable liquid use outside DC switchgear room door
68	X		Review procedures to ensure confinement pressure sensing block valves are open
82	X		Update battery maintenance program
101	X		Improve shift log entries
102	X	W	Improve controls over operator aids (documents)
126	X	T,W	Issue simulator training plan and develop exercise guides
131			Improve waste generation reduction program

1/ Refers to number assigned by UNC in their draft Safety Enhancement Program Plan, and relates to recommendations for improvements made by one or more EH Review Teams since Chernobyl.

2/ Consultants generally have endorsed EH Review Team's recommendations. This column refers to specific suggestions by each of the consultants (Ls = Lewis, Lt = Leverett, P = Pigford, R = Roddis, T = Tape, W = Wilkinson).

EH Rec.	Should Accelerate	Consult. Rec.	Scheduled in the SEP for Completion by July 1, 1987
7	X	R,W	Develop procedures for shutdown from outside control room in event of fire
12	X		Reexamine wind damage potential for buildings 181-N and 182-N
22		L,P,T	Upgrade analytical tools for thermal hydraulic analyses
35		P,R,W	Improve pressure tube rupture analysis
70	X		Review seismic adequacy of control room ceiling and cabinets
71	X		Review potential for damage to Building 109-N batteries from falling objects
72	X		Review whether concrete blocks near Building 181-N can damage batteries by falling
73	X		Same for Building 182-N. Also review buried tanks and lines and vertical tanks near Building 182-N for seismic and wind loading
74	X		Review silo near Building 182-N for strength and pipe connection deformation
75	X		Review portable lighting for seismic stability
76	X	W	Monitor hydrogen levels in the inert gas
84	X		Revise Emergency Planning documentation to clarify responsibilities
86	X	P,T,W	Improve emergency training for shift managers
90	X	W	Ensure control room can be operated when releases require breathing air equipment or protective clothing
94	X		Evaluate feasibility of replacing liquid chlorine facilities
103	X		Improve tag and lockout system

EH Rec.	Should Accelerate	Consult. Rec.	
			Scheduled in the SEP for Completion by July 1, 1987 (continued)
104	X	W	Improve training and knowledge of when graphite burns
			Scheduled in the SEP for Completion by October 1, 1987
6	X		Assure tight administrative control of cable spreading room
9		P	Determine effect of pressuring confinement with significant burden of fission products
30		P,T	Determine decontamination factor of charcoal filters for hydrogen iodide
31	X	R,T,W	Develop aggressive program to make use of commercial reactor information
36) 37) 38)	X 3/	R,W	Further enhance surveillance programs for pressure tubes to include: sensitive nondestructive examinations (NDE) of 50 to 100 tubes; metallurgical examination of at least two tubes; and tests on any effects of hydrogen on defect growth
42		W	Perform tests to ensure pressure tubes cannot be failed by local graphite offsets
43	X	W	Quantify pressure tube strains/stresses from graphite offsets
44		W	Perform experimental tests of blocks and/or tubes of graphite if necessary to obtain reliable values
45	X	W	Develop methods to monitor graphite "stack" distortions
48	X		Use operating experience to evaluate precursors to severe accidents

---

3/ We understand that the contractor has recently taken action to start this program in April.

EH Rec.	Should Accelerate	Consult. Rec.	Scheduled in the SEP for Completion by October 1, 1987 (continued)
49	X	Lt,T,W	Conduct peer review of emergency operating procedures
52			Complete necessary changes in control room
56	X	Lt,P,R,T,W	Evaluate hydrogen control equipment
59	X	P	Confirm present assumptions on Loss-of-Coolant Accidents (LOCAs) caused by small openings in pressurizer
61		P	Evaluate reliability of decay heat removal methods
62	X	Lt,P	Reanalyze the hypothetical accident in N Reactor safety analysis report (NUSAR) using current radioactive source term methodology
65	X	P	Analyze severe accident initiated by propagating failure of pressure tubes
69		W	Include common mode failures in Probabilistic Risk Assessment (PRA)
77		W	Reevaluate reliability/availability of gas inerting system
78	X	Ls,P,T,W	Complete current PRA
79		Ls,P,R	Base computer models on current PRAs
87		R,W 4/	Conduct interim upgrade of emergency control center
91	X		Establish alternate evacuation routes from N Reactor building
92	X		Improve capability to provide immediate aid in emergencies

---

4/ This is now complete.

EH Rec.	Should Accelerate	Consult. Rec.	Scheduled in the SEP for Completion by October 1, 1987 (continued)
93	X		Correct deficiencies in plant annunciating systems
95	X 5/		Improve personnel accountability in evacuations
96	X		Expand scope of annual facility safety review
97	X		Improve identification of plant material deficiencies
98	X		Reduce number of fluid system leaks
108	X		Assure independent reporting channel for Quality Assurance (QA) organization works effectively
111	X	W	Establish system for control of non-conformance report tracking
114	X	W	Provide for timely closure of QA audit findings
115	X		Develop master list of activities subject to QA auditing
123	X		Require all fuel handling to be under direct supervision of certified individual
129		R,W	Improve system for review of offsite operating experiences
132	X		Provide more comprehensive validation system for computer codes used for calculating operating limits of N Reactor

---

5/ A new automated system has been installed.

Candidates for Possible Schedule Improvement
Items Scheduled for FY 1988 and Beyond

EH Rec.	Should Accelerate	Consult. Rec.	Title
			FY 1988
3	X		Pursue efforts to reduce primary system leakage
85			Provide for operational support during an emergency
100			Improve the execution of the provisions of the "Fitness for Duty" programs
110			Improve handling, etc., of chemicals, etc., in accordance with certain QA standards
116	X		Build on the QA program to emphasize prevention of conditions adverse to quality
124			Expand the training and certification program to provide skills related to "non-credible" accident assessment, etc.
130			Develop a more comprehensive and integrated trend analysis program
			FY 1989
2			Raise sensitivity of detection of small coolant leaks
113			Provide suitable storage for "Lifetime Records"
			FY 1990
60			Protect containment relief valves from blockage by debris

Compilation and Status of N-Reactor Recommendations

Following is a compilation of the actions being taken to improve the operation of the DOE's N Reactor at Hanford, Washington. These actions were recommended by DOE safety reviews and by six independent experts. The compilation is organized by category and by the status of the action: Completed, In Progress, and Accelerated.

Actions Completed	
Hydrogen Monitor in N Reactor Stack Installed and Operating	10/86
Emergency Response Facility for N Reactor Operational	11/86
Tube Rupture Propagation Analysis Successfully Completed	11/86
Emergency Response Training for all Supervisors	11/86
17 Pressure Tubes Examined	11/86
Seismic Analysis for Critical Tanks Successfully Completed	11/86
Training and Certification of Load/Unload Operators Completed	11/86
Management/Organizational Changes Within N Reactor Staff	10/86

Actions in Progress	Start Date
Pressure Tube Surveillance Equipment in Development	9/86
Graphite Growth Measurements and Surveillance Plan Development	9/86
Probabilistic Risk Analysis	4/86
Hydrogen Generation, Transport and Source Studies	9/86
Control Room Habitability Modifications	10/86
Enhancements to Training	10/86
Qualification of System Components Under Accident Conditions	11/86

Actions Being Accelerated	Acceleration
Increased Testing of Confinement System Components	
- Perform Reliability Testing of Components	12 Months
- Increase Seal Leakage Tests	6 Months
- Evaluate Alternate Modes of Operating Confinement to Minimize Releases During Accidents	12 Months
Increase Surveillance of Reactor Pressure Tubes	
- Remove 4 Tubes for Destructive Examination	6 Months
- Perform NDE of 60-100 Tubes in Reactor Including Eddy Current, Ultrasonic and Profile Testing	6 Months
Increased Safety Systems Inspections	
- Confinement Systems	6 Months
- Primary System Components	9 Months
- Emergency Cooling System Components	12 Months

Accelerate Engineering and Construction of Plant Modification	
- Engineering for Above Changes	12 Months
- Complete Upgrades of Graphite Cooling System	6 Months
- Engineering to Allow Completion of Confinement Vent Valve Qualification Earlier Than Planned	24 Months
- Engineering to Enhance Reliability of Emergency Cooling Systems by Near-Term Changes	6 Months
- Accelerate Control Room Habitability	3 Months
Administrative Improvements and Requirements	
- Improve Operating Procedures	6 Months
- Training Improvements	6 Months
- Improve Work Control Procedures	6 Months
- Improve Storage of Chemicals	3 Months
- Improve QA Procedures	6 Months
- Approximately 50 Items Accelerated an Average of 10 Months	

Additional Major Consultants Issues

Physical and Procedural Changes to Reduce Radionuclide Release to the Soil Columns	
- Reduce Primary System Leakages by Replacing Valves and Repairing Seals	6 Months
- Install Fuel Damage Arrestor	12 Months
- Start Cleanup of Fuel Basin Floors	12 Months
- Begin Installation of Emergency Dump Basin Liner	12 Months
Plant Modifications for Improved Hydrogen Control	
- Begin Installation of Hydrogen Monitoring Systems	Months
- Begin Installation of Near-Term Hydrogen Mitigation Systems in High-Risk Areas of Confinement	8 Months

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

N REACTOR SAFETY

A POST—CHERNOBYL ASSESSMENT

DECEMBER 1986

Department of Energy
Washington, D.C. 20585

THE SPECIAL REVIEWS

- APRIL 28 : SWEDEN REPORTS RADIOACTIVITY, PROBABLY FROM SOVIET UNION
- MAY 2 : SECRETARY HERRINGTON REQUESTS SPECIAL DEPARTMENT REVIEWS OF N REACTOR
- MAY 5 : EXPERTS (RODDIS, ET AL.) REQUESTED TO ASSIST IN REVIEWS OF N REACTOR
- MAY 14 : NATIONAL ACADEMY OF SCIENCES ASKED TO REVIEW MAJOR DOE REACTORS

Department of Energy
Washington, D.C. 20585

IMPLICATIONS OF CHERNOBYL TO N REACTOR

- The Special Consultants' Review -

SIX EXPERTS REQUESTED TO REVIEW N REACTOR

- MILES C. LEVERETT
- HAROLD W. LEWIS
- THOMAS H. PIGFORD
- LEWIS H. RODDIS
- GERALD F. TAPE
- EUGENE P. WILKINSON

Department of Energy
Washington, D.C. 20585

SCOPE OF SPECIAL CONSULTANTS' REVIEW

- REVIEW FACTS & FINDINGS ABOUT CHERNOBYL
- EVALUATE N REACTOR IN LIGHT OF CHERNOBYL
- ASSESS WHETHER DOE REVIEWS OF N REACTOR PROPERLY ADDRESS CHERNOBYL ISSUES

Department of Energy
Washington, D.C. 20585

MAJOR FINDINGS OF THE SPECIAL CONSULTANTS' REVIEW

- CHERNOBYL:

  A REACTIVITY ACCIDENT SUCH AS OCCURRED AT CHERNOBYL IS NOT POSSIBLE AT N REACTOR.

- DOE SAFETY REVIEWS:

  100+ ACTIONS RECOMMENDED BY DOE ES&H REVIEW TEAMS SHOULD BE ACCEPTED.

- N REACTOR IN LIGHT OF CHERNOBYL:
  - CONCERN EXPRESSED ABOUT DIFFERENCES BETWEEN N REACTOR AND CURRENT REQUIREMENTS FOR LWRs
  - ACTIONS IN ADDITION TO THOSE RECOMMENDED IN DOE SAFETY REVIEWS SHOULD BE UNDERTAKEN
  - EXPAND OVERSIGHT BY INDEPENDENT GROUPS

Department of Energy
Washington, D.C. 20585

RECOMMENDATIONS FOR CONTINUED OPERATION

- FOUR CONSULTANTS FIND CONTINUED OPERATION ACCEPTABLE, PROVIDED:
  - RECOMMENDED IMPROVEMENTS ARE ACCOMPLISHED
  - RESULTS OF ANALYTICAL STUDIES ARE ACCEPTABLE

- TWO CONSULTANTS RECOMMEND SHUTDOWN UNLESS GOVERNMENT DETERMINES THAT N REACTOR IS NEEDED TO PRODUCE MATERIAL REQUIREMENTS FOR NATIONAL DEFENSE.

Department of Energy
Washington, D.C. 20585

EXAMPLES OF SPECIFIC RECOMMENDATIONS

- IMPROVE OPERATOR TRAINING FOR ACCIDENTS, INCLUDING USE OF SIMULATOR
- PROVIDE FOR REMOTE REACTOR SHUTDOWN
- MAKE ADDITIONAL UPGRADES TO EMERGENCY CORE COOLING SYSTEMS
- INCREASE SURVEILLANCE OF REACTOR COMPONENTS AND SYSTEMS
- TEST THE CONFINEMENT UNDER SIMULATED ACCIDENT CONDITIONS
- INSTALL HYDROGEN MITIGATION SYSTEMS
- STOP DISCHARGING PRIMARY COOLANT TO SOIL

RESULTS OF DOE ES&H REVIEWS

- SPECIAL REVIEW OF GRAPHITE FIRE PROTECTION:

  REPORT ISSUED MAY 1986, CONCLUDED THAT THE GRAPHITE IS WELL-PROTECTED FROM THE DAMAGING EFFECTS OF POSTULATED FIRES OR EXPLOSIONS.

- SPECIAL REVIEW OF CONFINEMENT:

  REPORT ISSUED MAY 1986, CONCLUDED THAT THE CONFINEMENT SYSTEM MEETS FEDERAL REQUIREMENTS FOR PROTECTING THE PUBLIC.

- DESIGN REVIEW:

  REPORT ISSUED SEPTEMBER 1986; NOTED A NUMBER OF AREAS WHERE UPGRADES SHOULD BE MADE TO BE MORE COMPARABLE TO CURRENT LWR PRACTICES; GRAPHITE GROWTH WILL LIMIT LIFETIME OF N REACTOR AND SHOULD BE CLOSELY MONITORED.

- REVIEW OF OPERATIONAL SAFETY:

  REPORT ISSUED JULY 1986; NOTED A NUMBER OF AREAS FOR IMPROVEMENT WHICH INCLUDE EMERGENCY READINESS, RADIOLOGICAL PROTECTION, TRAINING AND QUALITY ASSURANCE.

Department of Energy
Washington, D.C. 20585

RESULTS OF OTHER REVIEWS

- GAO:

  REPORT ISSUED AUGUST 5; N REACTOR IS NOT LIKE CHERNOBYL; CONCLUDED THAT MAJOR UPGRADES WILL BE NECESSARY IF THE REACTOR IS TO OPERATE BEYOND MID-1990s.

- STATE OF OREGON CONSULTANTS:

  REPORT ISSUED AUGUST 27; REQUESTED IMMEDIATE ACTION TO IMPLEMENT DOE ES&H RECOMMENDATIONS.

- NATIONAL ACADEMY OF SCIENCES:

  PANEL AT N REACTOR DECEMBER 15, 16; INTERIM REPORT EXPECTED SPRING 1987.

SUMMARY

- SECRETARY HERRINGTON RECOGNIZED NEED FOR IMPROVEMENT IN SAFETY & ENVIRONMENTAL PRACTICES AT DOE FACILITIES; INITIATIVES BEGUN IN 1985.
- BECAUSE OF CHERNOBYL, SPECIAL EMPHASIS GIVEN TO N REACTOR.
- CONSULTANTS HAVE AFFIRMED OUR EFFORTS TO DATE, BUT RECOMMEND ADDITIONAL ACTIONS.
- CHANGE UNDERWAY, COMPLETION WILL TAKE TIME AND MONEY.
- THE SECRETARY REMAINS COMMITTED TO ASSURING THAT THE DEPARTMENT OPERATES SAFELY IN MEETING ITS NATIONAL DEFENSE RESPONSIBILITIES.

Department of Energy
Washington, D.C. 20585

ACTION PLAN

- A SAFETY ENHANCEMENT PROGRAM FOR N REACTOR WAS DEVELOPED BY THE CONTRACTOR AND WILL BE ACCELERATED.
- EXTENSIVE MODIFICATIONS WILL BE MADE, REQUIRING THAT N REACTOR BE OUT OF SERVICE FOR SEVERAL MONTHS.
- NEW EQUIPMENT AND PROCEDURES ARE BEING INSTALLED AT N REACTOR TO HELP ASSURE ACCIDENT FREE OPERATION THROUGH ITS REMAINING LIFETIME.

LOUIS H. RODDIS, JR., P. E., C. ENG.
CONSULTING ENGINEER
CHARLESTON, SOUTH CAROLINA 29401

October 3, 1986.

The Honorable John L. Herrington, Secretary
U.S. Department of Energy.
1000 Independence Avenue, S.W.,
Washington, D.C., 20585.

Dear Mr. Secretary:

As one of the six independent consultants you asked to report on the impact of the Chernobyl-4 disaster on the operations at the "N" reactor at Hanford, WA. I submit the following report.

SUMMARY:

1. The Advisory Committee on Reactor Safeguards in 1966 identified the basic hazards of the "N" reactor as follows:

> " The Committee again points out that radiological consequences in the unlikely event of a severe reactor accident at the N-Reactor during 4000 MW(t) operation would exceed the dose guidelines now used for licensed power reactors."

I believe this situation is unchanged today.

Therefore I recommend that the Department shut down the "N" reactor unless a positive judgement is made that the requirements for defense material warrants accepting public hazards exceeding those of commercial reactors.

2. If continued operation for the next several years is considered to warrant acceptance of these hazards, then a short term Action plan should be provided and executed based on the various sources of recommendations identified in the "Recommendations" section below. Briefly these include the 88 recommendations of the Departmental review teams that have just reported to you and some additional steps, especially those aimed at reducing the potential for a hydrogen explosion.

With these changes operation at the present power levels and core loadings can continue until 1990-1991 without risks increasing much over those now existing.

3. If continued production of Defense materials is required long term, replace the "N" reactor by a less unique design, with provision for accident mitigation similar to commercial reactors. This will be a challenging task, but is not a new idea. It was studied extensively in the 1982 time frame, but never executed, apparently for economy reasons.

SCOPE OF REPORT:

As one of six individual consultants asked to make recommendations on the "N" reactor in the light of the Chernobyl-4 accident this report is submitted. Appendix 1 contains the charge letter and my qualifications. The other appendices include a bibliography and the list of joint briefings and special meetings. The discussion, conclusions and recommendations below are based on the material and meetings listed therein and on my experiences in the nuclear power area since 1946. I have also benefited from discussions with the other five consultants; Dr. M. C. Leverett, Prof. H. W. Lewis, Prof. T.H. Pigford, Dr. G.F. Tape, and Mr. E.P. Wilkinson, but this report is entirely on my own responsibility.

I wish to thank Ms. Marilyn S. Smith, Special Assistant to the Director of Energy Research for her material assistance in acting as Departmental contact and Secretary to this group of Expert Consultants of which I have been the Administrative Chairman. Also to Mr. John R. Ireland and Dr. Glen Graves of the Los Alamos National Laboratory for their assistance as Technical Staff for our group. Without the assistance of these three individuals our task would have been much more difficult.

I would like also to thank the many members of the Department of Energy staff, and of members of their contractor's staffs, who prepared information and answered our many questions. Where information was available it was fully and factually made available. Several on-going studies were instituted to study specific additional matters which we identified.

LESSONS LEARNED:

From the two major power reactor core melt accidents of the past decade, Three Mile Island-2 and Chernobyl-4, there are several lessons to be drawn. They confirm the results of over a score of lesser core melt incidents.

1. The unexpected event can occur, often very quickly from either design or operator error, or both.

2. Gross core melting can occur with release of radioactivity from the system.

3. With proper design some amount of hydrogen reaction can be contained or prevented, thus reducing the release of radioactive products into the surroundings and mitigating the major effects of the accident.

ACCIDENT DESIGN.

World standards for accident design usually provide for a "most credible accident" which the reactor is designed to contain without release of radioactive products.

For the U.S. industrial power reactors, for the USSR power reactors, and for the "N" reactor this is basically to contain the mechanical energy of the coolant pressure and state change energy released by a double ended break in the largest pressure piping.

In addition the U.S. requires for commercial power reactors (10CFR50 Appendix K) that a non-mechanistic hypothetical accident which releases 50% of the fission products into the reactor building not release radioactive products to the surroundings to an unacceptable amount.

Such a criteria is not included in the USSR RBMK type reactor accident design standards. At Chernobyl a major release of radioactivity into the steam occurred almost instantanously with the multiple tube rupture which broke open the reactor vault by steam pressure, followed by hydrogen evolution and probable explosion.

Likewise the "N" reactor design is such that an instantaneous postulated radioactivity release accident cannot be handled during the first pressure venting phase of the accident. The "N" reactor design was premised on the assumption that this radioactivity release will not occur until after the first overpressure surge has been relieved by venting after several minutes. This assumption is fundamental to the confinement design of "N" reactor.

SIMILAR ACCIDENT.

The Chernobly-4 accident had three basic causes.

a. An incredible series of operating errors.
b. A basic design (positive void coefficient) which made the operation and control especially tender.
c. An accident mitigation system which did not provide containment if more than one tube rupture occurred simultaneously.

While no design can eliminate all operating errors the training and procedures at "N" reactor appear to be strong enough to reduce the possibility of gross maloperation.

Because of the negative void coefficient with the present loading and with the strong reactivity controls on the "N" reactor I consider it impossible for an accident exactly like the one that occurred at Chernobyl-4 to occur with the "N" reactor.

On the other hand a major accident not now covered in the "N" Reactor Upgraded Safety Analysis Report (NUSAR) cannot be ruled out. Such an event including multiple tube ruptures and the evolution of large amounts of hydrogen has not been thoroughly evaluated, in my opinion, in the NUSAR.

Except for the neutronics it does not appear likely that the graphite will contribute to the early stages of an accident, though it may enter chemically if a prolonged high temperature event is precipated by metal-water or other initiating events.

I have no doubt that the "N" reactor is of a safer design than Chernobyl-4, and is currently being competently operated. I do not believe that any experiment with the operating "N" reactor would be performed without very rigid controls and supervision.

Because of the physically large area around the "N" reactor the close in effects on large bodies of population that occurred at Pritipat would not occur. The emergency plan should however be better integrated with the adjoining State governments as recommended in the 8/5/86 GAO report.

PUBLIC PERCEPTIONS OF DOE RESPONSIBILITY.

The primary responsibility for safe operation of the DoE reactors is properly placed on the line organization and their contractors. Quite recently the oversight responsibility has been placed under another Assistant Secretary, in ESH. This is a good step, but to work effectively and be credible it needs some public participation and some position of authority in not allowing operation to proceed if unsafe.

The now organized system of Technical Safety Appraisal Reviews and Design Reviews need to have a parallel action plan system in the line organization which will insure the funding and execution of recommendations. It is not at all clear now how this will in fact work, especially with the time consuming Governmental budget process, which puts no special emphasis on safety.

In the commercial field the NRC authority to suspend operations until deficiencies are rectified has had success in getting the safety work done, often years before the utility can recover the costs if ever. Such a shutdown authority in the hands of ESH might be considered. I note that the Secretary has delegated such authority to the Assistant Secretary for Environment, Safety and Health on September 12, 1986 in DOE N 5480.2.

At present the fiscal responsibility of the budget and appropration process dominates over the strictly safety process. This is a real distinction between the directly Federal operated reactors and those in the licensed commercial field, including licensed Federally owned utilities.

While it is intended that the recommendations of ESH are to be made public, in the form of the various appraisal team reports, the entire process would be more credible if a permanent system of outside overview were established. This ad-hoc review of six outside consultants is a one time thing. I trust that our reports will be made public, but what is needed is a more permenant system of overview.

Even the National Academy of Science overview appears to be a one time response. I would suggest that a separate permanent public outside review group would be helpful to the DoE. The Advisory Committee on Reactor Safeguards is such a body for the NRC. The ACRS has an established appointive system by the NRC and operating procedures and staff, and is composed of technically reputable persons from academia and industry (retired persons). A similar body appointed by the Secretary composed of qualified individuals, could add credibility to the Departmental Safety Review process.

The present contractor (UNC) is due to be replaced or re-established by October 1987. With the great importance of the management philosophy and attitude in the safe operation of the "N" reactor, it is difficult to place long term credence on how the new contractor will approach this problem until the selection is made.

The present contractor is a "special" member of INPO. I would suggest that the Department have this contractor, and his successor, make full use of the overview services of INPO, in the operations, maintenance, training and emergency preparedeness fields.

ENERGY COMPARISIONS:

There are three basic energy forms stored in a power reactor system in addition to the nuclear energy represented by the fuel and fission products.

1. Steady state stored energy. This includes mechanical energy in the form of the pressure of the coolant, and of the change of state energy available in water heated above the vapor pressure of the ambient atmosphere. While this is the smallest of the contained energy sources available it is the usual basis of the "most credible accident" design of the coolant pipe break. Graphite lattice stored energy "Wigner energy" would also be included in this category for a graphite moderated reactor, but at the operating temperatures of Chernobly-4 and "N" is of negligible quantity.

TABLE I

REACTOR PARAMETER COMPARISONS

		TMI-2	Chernobyl-4	N-Reactor
A.	Energy Potentials (All X10^6 MJ)			
	1. Steady-State Stored Energy(1)	0.39	1.91	1.89
	2. Chemical Stored Energy (Metal/Water Reactions)	0.14	1.14	2.17(2)
	3. Chemical Stored Energy (Graphite Exothermic Reactions)	0.00	0.66	0.59
B.	Potential H_2 Generation(3) (All X10^6 SCF)			
		0.39	3.30	6.25(2)
C.	Full-Power Adiabatic Heat-Up Rate (K/s)			
		93.0	53.0	72.0
D.	Time to melt Zr after scram (s) (Assumes 1% decay heat)	590.0	1040.(3)	765.0(3)
E.	Core Contents (metric tons)			
	1. Zirconium	21.0	177.0	195.0
	2. Uranium Metal	0.0	0.0	365.0
	3. Graphite	0.0	2000.0	1800.0

---

[1] Includes structural, fuel, thermodynamic stored energy, and graphite stored energy for Chernobyl-4 and N-Reactor.

[2] Includes uranium metal-water reaction.

[3] Neglects any graphite reactions.

2. Chemical Metal-Water. This depends on temperatures achieved, and the materials involved. Principally metal-water reactions occur with steam and uranium metal, zirconium metal or alloys, and other active metals that may be present such as steel or titanium. These reactions usually release heat, and can be self sustaining, especially if aided by residual nuclear heating. The reactions evolve hydrogen gas, among other products, which can lead to deflagration or detonation when oxygen is present in the surroundings.

3. Chemical Graphite. At even higher temperatures materials such as graphite can react with oxygen, which releases heat, or with steam, such latter reaction absorbing heat. This can be a large energy source with various explosive and other products being released.

The magnitude of these various energy forms is shown in Table 1, page 5a, which compares the energy available at Chernobyl-4, Three Mile Island-2, and "N" reactors. (Prepared by Mr. John Ireland of the LANL.) Even without the graphite chemical energy, it is clear that the available chemical energy from metal-water reactions is significantly greater in "N" and Chernobyl-4, than in TMI-2. The graphite energy will probably not be involved unless a long r[illegible] major accident occurs, as at Chernobyl-4.

Table 1 also shows that the potential hydrogen evolution at the "N" reactor is 20 times that of a TMI-2 and twice that of a Chernobyl-4.

HYDROGEN CONTROL:

Both at Three Mile Island-2 and at Chernoblyl-4 the large scale generation and release of hydrogen into the surrounding atmosphere was unexpected. The release into the TMI-2 containment resulted in a deflagration in a local area that did little damage. Such releases can be contained in normal U.S. commercial containments without catastrophic failure. Some containments were already inerted before the TMI-2 accident, subsequent action has required hydrogen control, either by inerting or by igniters, in many U.S. commercial plants. Over 20% are inerted in the containment during operation. (not during startup)

Aside from the reactor core itself, which is inerted for temperature and oxidization control of the graphite, "N" reactor does not now have any hydrogen control systems. "N" does not now even have a hydrogen indicating system on the inerting gas immediately around the graphite stack itself, though it has recently been recommended that such instrumentation be installed.

Chernobyl-4 did have hydrogen indicating and dilution control systems (dilution fans) in the pump and piping spaces. It also apparently had a hydrogen indication system as part of the graphite stack inert atmosphere clean-up system. Of course since the Chernobly-4 accident involved massive release of steam from multiple tube ruptures, the initial boundary rupture was by steam overpressure, any hydrogen explosions occurred moments later.

Within the heavily shielded Zone One of the "N" reactor there are a number of compartments with varying degrees of intercommunication of their atmospheres. There is little provision for mixing and none for hydrogen explosion prevention. As will be seen below I believe that some form of hydrogen control, preferably by inerting, be put in place in Zone One as a matter of high priority.

RISK/BENEFIT

Almost all human endeavors involve some balancing of risk with benefit, since nearly everything we do has some degree of risk.

The possibility of an accident involving major core damage in operating the "N" reactor is probably about the same as that from any commercial reactor. Where there is a significant difference is in the mitigation of the consequences of an accident where I believe such measures are much less than those present in commercial reactors. Thus the overall risk of release of radioactivity to the environment from "N" is significantly larger than from a commercial reactor. To the nearby population this risk is reduced somewhat by the large area of low population density (including worker population) surrounding the reactor.

This increased risk was originally accepted by the AEC because there were then in operation several older production reactors of even less safe design. These older units are all now shut down.

The benefits are two-fold, electric power generation, and the production of materials for the U.S. Defense Programs.

As regards the need for electric power generation in the region I believe I can render some judgement on the relationship between the benefits and the risks, since my technical competency covers both of those areas. The most recent forecast of Electric Power Supply and Demand for the period 1986-1995 from the North American Electric Reliability Council(June 1986) shown the North West Power Poolwinter load demand going from 32,359,000 KW in 1985 to 38,573,000 KW in 1995 or a growth rate of 1.3%. During the same time period the available resources increase from 46,509,000 KW to 48,025,000, a growth of .4%. This leaves a reserve margin of 24% in 1995.

Without "N" the margin becomes 22% assuming that it is not replaced with an electricty producing unit. None of the above figures include the WPPSS units 1 and 3 which are in mothballs, and for which there is public discussion concerning their total abandonment. Because of the favorable rate paid for steam the replacement power costs may be higher, but with the "N" reactor constituting at most 2% of the energy this effect would not be large.

From this I cannot believe that the "N" reactor electricity production is essential to the area, and indeed if this were it's only purpose I would urge that it be shutdown permenantly immediately.

It is of course impossible for me to arrive at any realistic Risk/Benefit conclusion about the need of the "N" reactor for Defense materials production. However, since it is in operation, and in past years serious consideration has been given to its replacement, or major rebuilding, I can assume that competent Governmental authorities consider that the continued operation is essential to the public good and are willing to assume the increased risk over a commercial licensed unit, but I believe this evaluation should be reconfirmed.

ADVISORY COMMITTEE ON REACTOR SAFETY (ACRS) REVIEWS.

Prior to the separation of the NRC from the ERDA/DOE the ACRS made a number of reviews of the "N" reactor. These are discussed in Appendix B to the July 1986 Design Review but three items are not disposed of in that review, because they involve policy decisions beyond the scope of the Design Review Group. These are:

a. The ACRS never made their usual determination that the "N" reactor could be operated "without undue threat to the public health and safety". Instead they determined that "N" reactor operation was acceptable because it did not increase the reactor hazards already there (old production reactors). These are now all shut down and the only two other now operating reactors are in containments, one operating under NRC license, the other under DOE.

b. The ACRS noted that operation of the "N" reactor is only justified by production requirements.

c. The ACRS noted that hazard of the "N" operation exceeds that of licensed reactors. While not explicit in their letter this appears to be because of the lack of containment. The exact statement in the March 22, 1966 letter (declassified in 1975) is:

> "As indicated in our letters of May 20 and September 17, 1965, the Committee still believes that the potential hazards associated with the Hanford reactors (as they are now confined) exceed those of licensed reactors. The Committee again points out that radiological consequences in the unlikely event of a severe reactor accident at the N-Reactor during 4000 MW(t) operation would exceed the dose guidelines now used for licensed power reactors.

> The Committee believes that the operation of the N-Reactor with the new dual purpose fuel will not increase the existing hazard (note: no longer present in 1986) to the health and safety of the public. The Committee continues to believe that continued operation of the N-Reactor without further safeguards can only be justified by production requirements."

This situation may be beyond the purview of the Design Safety Review Team, but is certainly within the responsibility of the Secretary.

"N" STATUS SHORT TERM.

The Special Safety Team made four recommendations for improvement in the "N" reactor in their May, 1986 report.

The Technical Safety Appraisal Team made fifty-one recommendations in their July 1986 report. While all are in one way or another connected to safety, and form an imposing number for an operating reactor, I find one especially serious. This is QA.16, wherein a long standing Corrective Action Request (CAR) on the confinement seals, had been cancelled without the work being done.

At the request of the UNC management a Safety Assessment of the "N" Reactor was made by INTEX in 1983. This report of June 16, 1983 (the Dietrich report) was made available to us. It apparently was not reviewed by the Technical Appraisal Team. The INTEX report made a large number of recommendations in the Programmatic, Training and Technical Assessment areas. Some of those items appear to still be unresolved.

The Design Review Team made nine principal and a large number of additional recommendations in the course of their design review as reported in their July 1986 report. They point to a number of serious long term problems, which should be given immediate attention. As discussed in the section immediatly above they identified a major policy issue as being beyond their scope.

All three of these teams seem to have made competent reviews in their areas of coverage, and I support all of the recommendations. The INTEX report recommendations are also supported by me.

The three safety review teams have made in total 98 separate recommendations, when the duplications and overlaps are taken into account. A cumulative analysis of these has been prepared by ES&H.

An action plan is being developed and should be funded to put into place positive actions to fulfill these recommendations on a fixed schedule. I would suggest a target date of no later than October 1, 1987 for all to have been physically completed, since this date coincides with the selection of a new operating contractor.

A commercial power reactor faced with such a large number of recommendations would very likely be forced to close until all were completed.

ADDITIONAL RECOMMENDATIONS.

In addition to the recommendations made by the above three teams, I believe that three other matters should be corrected to a degree which I believe exceeds the recommendations of those teams. These items would normally arise in the Probability Risk Assessment (PRA) level 3 study recommended by the Design Team which study should be expedited. These items which I believe should be completed within one year and before the PRA is completed are:

1. Study the possible effects of a longitudinal split type break in an embrittled Zirconium alloy process tube within the graphite. If such a break can lead to stresses on adjacent tubes which can propagate in the core then something like the Chernobyl accident might be possible, especially if the separate tubing of the GSCS is affected. This separate cooling system is one of the key features of "N" which Chernobyl-4 did not have, and which is important in preventing some high temperature run-away metal water reactions.

2. Provide for hydrogen control by inerting Zone One of the confinement system during power operation. This zone is not accessible during operation because of radiation hazards, and the inerting would provide a degree of protection in the very areas most likely to be exposed to deflagration or explosion. A number of commercial reactors are operating with the equivalent volumes inerted during operation. Since inerting is used in most tanker ships the equipment is available commercially.

3. Providing better physical separation for the redundant emergency water pumping systems and water supplies for the ECCS and the GSCS. Provide protection and separate ventilation for the control room, or an alternate location, during accident conditions. These items are reported to be planned, but I was unable to verify their priority and schedule (See my July 13, 1986 letter appended.)

END OF LIFE

At the July 2, 1986 meeting at Richland, WA. this subject was discussed at some length. The nominal design life of the "N" reactor was apparently twenty years, a time that is now is the past. The more important assessment is how much remaining life is acceptable, without undue hazard. There are three principal areas of concern:

1. Normal mechanical and electrical components. While there are definite problem with auxiliary boiler tubes, valves with difficult to locate replacement parts, and the normal aging of electric cable, relays and electronic components, no definite end point stands out.

2. The graphite stack. After many years of slightly shrinking the graphite stack now seems to be growing at a rate that will result in contacting the roof thermal shield in three or four more years, say 1990. This is based on information more recent than that of the July 2, 1986 meeting. Besides the possible adverse effects of such contact the strains placed on the process tubes by this change is dimensions is appreciable. The graphite growth is a function of both power level and time, and can also be modified somewhat by flux peak shaping to spread the flux more uniformly. More study of this matter is needed to determine a final end point accurately.

3. The process tubes. By one criteria, which assumes the growth of a 5 mil crack existing in 1964 at startup, the ASME Section XI limiting fracture toughness will be reached in 1991 at present power levels. This limit is again dependent on time and power level. It also needs to be studied in more detail.

At present power levels and operating times I conclude that the situation will not change much from what it is today until about 1990-1991. Operation beyond that time would have to be predicated on data still yet to be developed to justify it.

LONG TERM PRODUCTION OF DEFENSE MATERIALS.

The "Productivity assurance program" is intended to extend the life of the "N" reactor into the 21st century. This program is laid out in the GAO report of 8/5/86, with the recommendation to the Congress that it be abandoned. While this may make a recommendation by me moot, I also believe that no efforts should be made to extend the life of the present "N" reactor by such major efforts. If the production capacity is needed a new reactor is indicated, as was studied in the 1982 time frame, and abandoned, apparently for economy reasons. My reasons are:

The "N" reactor if of an unique design, like nothing else currently in operation in the world. Thus it's experience base is accrued only at the rate of one reactor-year of experience per year. Nearly all other types of reactors are acquiring experience at the rate of from 25 to 50 reactor years of experience per operating year, from similar type units operating elsewhere. This makes the problems of predicting life expectancy and risk evaluation for the "N" reactor difficult.

On the other hand there are several known problems:

1. Embrittlement of the Zirconium alloy process tubes is occuring from the irradiation. This situation is leading to the recommendation that all tubes be replaced in the early 1990's. The ASME Section XI predicted stress limits will be exceeded in 1991 under some assumptions of original crack size. This will involve the creation of a new production line to produce these tubes, since there is no other US demand for such zirconium tubing.

2. Graphite growth in the stack is beginning to reverse from a long period of slow shrinking to a period of growth. By about 1989-1990 the growth will reach a positive 2 inches, an amount about equal to the maximium shrinkage. This change bends the process tubes and thereby increases the stresses therein, as well as otherwise affecting the various openings in the graphite stack, and the internal keys, some 15% of which are reported to already be broken. At about this point it will also contact the bottom of the roof thermal shield, with potential adverse effects.

3. The present design, based on the earlier production reactors, is very man-Rem intensive during the reloading cycle. To reduce this materially by automated operation, would involve further unique designs, which in the installation and maintence would be man-Rem intensive. In addition if extensive tube replacement or graphite replacement were done the resulting operation would involve much exposure. In ALARA terms this is very undesireable. "N" reactor uses about three times the commercial average of man-Rem / year, because of its design and age.(1700 vs 600 man-Rem/year.) One replacement study indicated that operation of a new reactor could be at about half the average (300 man-Rem/year)

4. The present confinement design has real possibilities of resulting in air releases in case of unexpected accidents even after inerting Zone One. It also has the problem of surface release of the accident water, which is to be pumped from confinement into the covered cribs on the bank of the Columbia River after an accident. Having seen the conditions put upon accident water release at Three Mile Island it would appear that this situation at the "N" reactor could not be tolerated in real accident conditions.

5. The redundancy of the emergency water supply systems and control room habitability needs to be corrected as suggested above. Many other conditions which are inherent in a late 1950 design of a unique system should be corrected in a new reactor. To rectify all these in the current design would almost certainly not be cost effective. Among other problems some 750-1000 gallons per minute of radioactive primary

coolant is released directly to a sand crib, and some apparently eventually surfaces as a spring discharging into the Columbia river.

6. Of the 55 General Design Criteria established by Appendix A to 10CFR50 the "N" reactor meets or exceeds 40. (NUSAR Vol.2) It does not meet 6, partially meets 1 and meets the intent of 8 (though I question this statement on criteria 41 concerning hydrogen evolution being negligible.) In addition it doen not meet Appendix K (in that the fission product release is considered to occur after the confinement venting) and it does not meet Appendix R (in circuit separation).

7. Until the post October 1987 operating contractor is designated it is not realistically possible to understand his operating philosophy.

CONCLUSIONS AND RESPONSE TO SPECIFIC QUESTIONS.

We have been asked the following specific questions:

Q1."The consultants will review the facts and findings surrounding the Soviet reactor accident at Chernobyl."
A. I have done so. See "Lessons Learned" and "Similar Accident" above.

Q2. Based on these facts and findings, the consultants will examine the N-reactor operations and safety procedures to ensure that all key technical questions and potential safety issues raised by the Soviet accident have been considered."
A. As discussed in the sections "Hydrogen control", "N" status short term" and "Additional recommendations" I believe a number of things must be done to continue operations for the next four or five years, and that even then the hazard to the general public will exceed that from a commercial reactor in the event of a severe accident involving core melting.

Q3. "The consultants will also examine the information and findings developed by the Department's safety reviews of the N-reactor to ensure that the relevant facts and findings from the Soviet accident have been addressed by the review teams."
A. I have reviewed the three teams output and believe they have been thorough. They did not look into some important policy questions, which are discussed in my sections "Risk/Benefit" and "ACRS reviews" above. I believe these matters warrent the Departments careful consideration. Some of these matters were discussed in my July 18, 1986 letter to Dr. Trivelpiece. In particular recommendations of the safety review teams are of little use until they are implemented.

SUMMARY OF RECOMMENDATIONS.

1. The ACRS identified in 1966 the basic hazards of the "N"

reactor as follows:

> "As indicated in our letters of May 20 and September 17, 1965, the Committee still believes that the potential hazards associated with the Hanford reactors (as they are now confined) exceed those of licensed reactors. The Committee again points out that radiological consequences in the unlikely event of a severe reactor accident at the N-Reactor during 4000 MW(t) operation would exceed the dose guidelines now used for licensed power reactors."

I believe this situation is unchanged today.

While I do not believe the possibility of a severe core melt accident at "N" reactor is much different than those of commercial reactors, the measures for mitigation of the effects on employees and the public of an accident by containment measures such as are used in commercial reactors is essentially lacking at "N". Therefore I recommend that the Department shut down the "N" reactor unless a positive judgement is made that the requirements for defense material warrents accepting public hazards exceeding those of commercial reactors.

2. If continued operation for the next several years is considered to warrent acceptance of these hazards then a short term Action plan should be provided and executed based on the various sources of recommendations identified above. These are in summary:

a. Eighty-eight recommendations combining all those from the Special Safety Team, the Technical Safety Appraisal Team, and the Design Review Team.

d. Three recommendations identified above as "Additional Short term recommendations".

e. Recommendations of the 1983 INTEL report.

f. Complete a Level 3 Probability Risk Analysis with emphasis on establishing a realistic end of life criteria and date.

g. Qualify a new operating contractor as "safety concious" at the top management level.

This should all be completed within one year, by October 1, 1987, which is the time set for the introduction of a new or reappointed operating contractor. With these changes operation at the present power levels and loading can continue until 1990-1991 without risks increasing much beyond those now existing. Lower power levels could give increased life. (See section "End of Life" above).

3. If continued production of Defense materials is required long term, replace the "N" reactor by a less unique design, with provision for accident mitigation similar to commercial reactors. This will be a challenging task, but is not a new idea. It was studied extensively in the 1982 time frame, but never executed, apparently for economy reasons.

4.I do not consider the proposed Production Assurance Plan for the"N" reactor to be an adequately safe long term solution. Continued operation without process tube and graphite stack replacement is going to be increasingly hazardous. Replacement will be a costly and difficult task both in dollars and in man-Rem.

Louis H. Roddis, Jr.,PE
Consulting Engineer.

cc: M.C. Leverett.
H.W. Lewis.
T.H. Pigford.
G.F. Tape.
E.P. Wilkinson.
M.S. Smith.
J.R. Ireland.
G. Graves.

REFERENCES JOINT BRIEFINGS AND SPECIAL MEETINGS:

Appendix 1. Charge letters, news release, and biography. Attached.

Appendix 2. Bibliography. Attached.

Appendix 3. Joint Briefings. Attached.

Appendix 4. Special Briefings. Attached.

Appendix 5. N-Reactor and Typical RBMK-1000 Comparisions.

Appendix 6. My letter of July 18, 1986 to Dr. Trivelpiece, Director of Energy Research, requesting additional information on behalf of all six of the consultants.

In addition to the Bibliographical material and Briefings and Special Meetings identified in the Appendices attached I had the following individual meetings concerning this subject:

May 9, 1986. GA Technologies, San Diego, CA. Msrs. H. Agnew, T. Johnson, A. Baxter.
Subject: Chernobyl-4 and graphite combustion.

May 10, 1986. Phone call. Dr. Thomas Cochran. Regarding his testimony of May 7, 1986 (Ref. 15.)

July 2, 1986. Richland WA. R.L. Ferguson Assoc. Msrs. R.L. Ferguson and John Honekamp. NW power pool generation planning and WPPS1/4 status.

The following individual references were also used.

R-1. 1986 Electric Power Supply and Demand, for 1986-1995. North American Reliability Council, June 1986. Princeton, N.J.

R-2. Northwest Energy News. February/March 1986. Northwest Planning Council.

R-3. Letter John Ireland Q-DO/TR-86-75 of June 27, 1986 to me. Subject: Energy Potential Comparisions for Chernobyl-4, N-Reactor, and TMI-2.

R-4. Letter John Ireland Q-DO/TR-86-74 of June 26, 1986. Subject: Adiabatic heatup-rate comparisions for Chernobyl-4, N-Reactor, and TMI-2.

R-5. DOE Notice DOE N 5480.2 of 19-12-86, expires 1-31-88. Subject: Emergency Suspension of Operations.

R-6. Draft Action Plan to address recommendations from the "N" Reactor. Forwarded 8/15/86. Including recommendations from:
Special Safety Review.
Technical Safety Appraisal.
Design Review.

R-7. UNC letter Gary L.Smith to Dr. Thomas H. Pigford, September 12, 1986. CORRAL anaylsis and Emergency Response Guide.

R-8. UNC letter Gary L. Smith to Dr. Thomas H. Pigford, September 15, 1986. "Hypothetical Dose Consequences Versus Increased Building Leakage".

R-9. Mary L. Walker, Assistant Secretary, Environment, Safety and Health, to The Under Secretary of September 3, 1986. Subject: Cumulative Analysis of EH's N Reactor Reviews.

R-10. Goetz K. Oertel, EH-30 to Mary L. Walker, EH-1 of August 28, 1986. Subject: Cumulative Analysis of N Reactor Reviews.

R-11. Victor Atiyeh, Governor, State of Oregon, to The Honorable John S. Herrington of August 27, 1986 and enclosure thereto entitled " A Report to Governor Vic Atiyeh on N-Reactor Safety" of August 12, 1986.

Appendix 1 page 1.

THE SECRETARY OF ENERGY
WASHINGTON, D.C. 20585

May 2, 1986

Dr. Louis H. Roddis, Jr., P.E.
P.O. Box 1513
Charleston, SC 29402

Dear Dr. Roddis:

The recent accident involving the Soviet reactor at Chernobyl has resulted in increased public concern about the safety of nuclear reactors, including those operated by the Department of Energy (DOE). The Department has only one reactor that has design characteristics that are even remotely similar to those of the damaged Soviet reactor. It is the N-Reactor located in Hanford, Washington. This reactor is used primarily for the production of nuclear weapons material, but it also produces electricity. Even though it has an outstanding safety record, I want to be absolutely certain that it is being operated safely and that there is no possibility of an accident similar to the one that occurred in the Soviet Union.

Shortly after being appointed Secretary of Energy, I approved a series of health, safety and environmental initiatives to examine all aspects of the Department's operations. One of these initiatives is the Technical Safety Appraisals of the Department's nuclear facilities to be conducted on a systematic basis over the next few years. In view of what happened in the Soviet Union, I have decided to accelerate the schedule for the planned safety review of the N-Reactor in order to complete that effort as soon as possible.

In addition, I have decided to invite an ad hoc group of experts, which I am asking you to chair, to assist the Department by ensuring that we have examined all of the key technical questions and probed into all the potential safety issues raised by the Soviet incident. While members of the group will be free to consult with one another in any way they choose, it is the individual expertise and individual advice, from each member, that the Department is seeking. The information and findings developed from the Department's safety reviews of the N-Reactor will, of course, be made available to each member of the group.

I have asked Dr. Alvin W. Trivelpiece, Director of the Office of Energy Research, to assist you in bringing this group together and conducting your review.

This is obviously a matter of great national importance and needs to be started as soon as possible. I know that until you have met and determined what needs to be done you cannot forecast when your work will be completed, but given the urgency I would hope that you could complete your review in a few weeks.

I greatly appreciate your willingness to help us in this important endeavor.

Yours truly,

John S. Herrington

John S. Herrington

OFFICE OF THE PRESS SECRETARY
WASHINGTON, DC 20585

DOENEWS

NEWS MEDIA CONTACT:
Gail Bradshaw, 202/252-5810

[illegible] page 3.

NUCLEAR

FOR IMMEDIATE RELEASE
MAY 5, 1986

HERRINGTON ASKS EXPERTS TO ASSIST IN REVIEWING SAFETY OF DEPARTMENT'S N-REACTOR

Energy Secretary John S. Herrington has established a special safety review panel, composed of nationally recognized scientific and technical experts, to help review the safety of the department's N-Reactor, near Richland Washington.

Louis H. Roddis Jr., consulting engineer and former President of Consolidated Edison Company of New York will chair the effort, assisted by Dr. Gerald Tape, former President of Associated Universities, Inc. Biographies of both are attached. Another three to four experts will be added over the next several days.

"The N-Reactor is the only one the department operates which has design characteristics even remotely similar to those of the damaged Soviet reactor," Herrington said.

"Even though it has an outstanding safety record, I want to be absolutely certain that N-Reactor is being operated safely and that there is no possibility of an accident similar to the one that occurred in the Soviet Union," Herrington added.

Each member of the special panel is being asked to provide candid, individual views in order to "assist the department by ensuring that we have examined all of the key technical questions and probed into all the potential safety issues raised by the Soviet accident.

-more-

The panel will have access to all available information about the accident at Chernobyl and about N-Reactor, including the department's internal safety reviews of N-Reactor, and will be assisted by DOE Director of Energy Research Dr. Alvin Trivelpiece.

The panel's activities will parallel a DOE review of the N-Reactor ordered last week by Secretary Herrington.

The internal review will be under the direction of Assistant Secretary for Environment Safety and Health Mary Walker and will involve three steps:

- A special safety review team begins on Monday, May 5, to look at specific aspects of safety, such as fire protection related to the graphite moderator used in the reactor. That review is expected to be completed within a few days.
- A DOE team also begins that day to review N-reactor's design and the safety upgrades which have been put in place since the plant was built. That is expected to be completed in about two months.
- A comprehensive DOE technical safety appraisal of the plant that originally was to have begun in September, 1986 has been rescheduled to begin May 19.

Technical safety appraisals are among initiatives which Secretary Herrington announced in 1985 to ensure the safety and environmental compliance of all of DOE's facilities.

The N-Reactor is a heavily instrumented, graphite moderated reactor that is cooled by normal water. Construction was completed in 1963. The primary purpose of the N-reactor is to produce nuclear material for national defense, but byproduct steam is sold to the Washington Public Power System for generating electricity. N-Reactor is operated for the DOE by UNC Nuclear Industries, Inc.

-DOE-

R-86-073

Appendix 1 page 5.

U.S. DEPARTMENT OF ENERGY
OFFICE OF THE PRESS SECRETARY
WASHINGTON, DC 20585

DOENEWS

NEWS MEDIA CONTACT:
Gail Bradshaw, 202-252-5806

FOR IMMEDIATE RELEASE
May 7, 1986

HERRINGTON FILLS OUT EXPERT CONSULTANT PANEL REVIEWING N-REACTOR

Energy Secretary Herrington today named four additional outside persons to the special panel whose members will review the safety of the department's N-Reactor, near Richland, Washington.

The four experts named today are:

Dr. Thomas Pigford, Chairman of the Nuclear Engineering Department, University of California, Berkeley;

Admiral Eugene P. (Dennis) Wilkinson, private consultant and former President and Chief Executive Officer of the Institute for Nuclear Power Operations;

Dr. Miles C. Leverett, private consultant and former research manager in nuclear reactor safety for the General Electric Company for 25 years; and

Dr. Harold Lewis, nuclear physics professor, University of California at Santa Barbara.

"These consultants are uniquely qualified to review the Chernobyl incident and N-reactor operations and safety procedures," Herrington said. "They add an extra dimension to the Department's efforts to ensure the safety of N-reactor."

The four join Louis H. Roddis Jr. of Charleston, S. Car [illegible] Gerald F. Tape of Washington, D.C., who were named May 5.

(MORE)

Each of the experts will examine the technical and safety aspects of the N-Reactor in light of the Chernobyl Reactor Accident. They will:

- o Review the facts and findings surrounding the Chernobyl accident.
- o Based on those facts and findings, they will examine N-Reactor operations and safety procedures to ensure that all key technical questions and potential safety issues raised by the Soviet accident have been considered.
- o Examine the information and findings from the department's own safety reviews of N-Reactor to ensure that the relevant facts and findings from the Chernobyl accident have been addressed by the DOE teams.

N-Reactor is owned by DOE and is operated primarily to produce nuclear materials for national defense.

-DOE-

R-86-074

(Note to Editors: Biographies of the six panel members are attached.)

Louis H. Roddis, Jr.
Brief Biography.

Louis H. Roddis, Jr. , Consulting Engineer, is a Director of Detroit Edison Company, Gould Inc., Gould Government Systems Inc., Hammermill Paper Company, and Research-Cottrell Inc. He is a consultant to several governmental agencies and private companies in the energy, utility and marine fields. He is active in the historic redevelopment of downtown Charleston, S.C.

After service in World War II, including the Pearl Harbor action, and while still an officer in the United States Navy, Mr. Roddis participated in the design of the USS NAUTILUS and other early Navy nuclear projects, serving under Captain H. G. Rickover, beginning in 1946. He became a member of the Atomic Energy Commission's Division of Reactor Development at its inception in 1949 and was the Deputy Director when he left in 1958 to assume the presidency of Pennsylvania Electric Company, one of the operating subsidiaries of the General Public Utilities Corporation. While with Penelec the company was awarded the industry's coveted Edison Award for extra-high voltage transmission development, and construction was begun on the three large coal fired mine mouth power stations now operated by Penelec.
Mr. Roddis joined the Consolidated Edison Company of New York in 1969 and served as President 1969-74. During that time Consolidated Edison acquired six large floating gas turbine power plants and became known as a leader in energy conservation in the electric and gas utility industry. After service in the Federal Energy Administration in 1975 he entered the consulting profession, first as President of John J. McMullen Assoc. Inc., and then as an independent consultant. Throughout his career in the marine and public utility fields, Mr. Roddis has been active in a wide variety of public service, charitable, industrial, and trade organizations. He was Chairman of the Maritime Research Advisory Board of the U.S. Department of Commerce and Chairman of the Energy Research Advisory Board of the U.S. Department of Energy. He was the only industrial member of the Environmental Panel of the President's Science Advisory Committee, which submitted the report"Restoring the Quality of our Environment" to President Johnson in 1965.
He was the honor graduate of the U.S. Naval Academy in 1939 and is a Captain (Ret.) in the Naval Reserve. He holds a Masters Degree in Naval Architecture and Marine Engineering from the Massachusetts Institute of Technology and is the author of numerous technical papers, including the section on Nuclear Power in Mark's Standard Handbook for Mechanical Engineers. He received the Atomic Commission's Outstanding Service Award in 1957 and the U.S. Department of Energy's Exceptional Service Award in 1984.
He was elected to the National Academy of Engineering in 1967, and is a Registered Professional Engineer in South Carolina, New York, Pennsylvania, New Jersey and the District of Colombia, and is a Chartered Engineer in the United Kingdom. He is a past Director of the Edison Electric Institute and of the American Gas Association, and a past President of both the Atomic Industrial Forum and the American Nuclear Society. He is a Fellow of the American Association for the Advancement of Science, the American Society of [illegible] Engineers, The Royal Institution of Naval Architects, and the American [illegible] Society. He is a member of the American Institute of Electrical and Electronics Engineers, the Society of Naval Engineers, the American Society of Naval Architects and Marine Engineers, the Association of Energy Engineers, the [illegible] Society, and the National Society of Professional Engineers.
Mr. Roddis was born in Charleston,S.C. in 1918. He and Mrs. Roddis [illegible] the historic district of Charleston.

P.O. Box 1513
Charleston, S.C. [illegible]

BEST AVAILABLE COPY

BIBLIOGRAPHY

1. V. G. Aden, et al., "Fuel Elements of the RBMK-1000 Reactor," Atomnaya Energiya 43 (4), 235-239 (1977) (translation).

2. A. P. Aleksandrov, et al., "Physical and Power Startup of the First Unit of the V. I. Lenin Nuclear Power Station, Leningrad," Atomnaya Energiya 37 (2), 99-107 (1974) (translation).

3. A. P. Aleksandrov and N. A. Dollezhal', "Development of Uranium-Graphite Channel Reactors in the USSR," Atomnaya Energiya 43 (5), 337-343 (1977) (translation).

4. E. P. Anan'ev and G. N. Kruzhilin, "Radioactive Safety Barriers in Nuclear Power Stations," Atomnaya Energiya 37 (1), 22-27 (1974) (translation).

5. R. W. Andrae, et al., "A Review of Four Safety Aspects of the Savannah River Production Reactor," Los Alamos National Laboratory letter report (Q-6) (August 1984).

6. M. Berman, "Hydrogen Behavior and Nuclear Reactor Safety," in Recent Developments in Hydrogen Technology, Vol. II (CRC Press, Inc., Boca Raton, Florida), Chap. 2, pp. 35-67.

7. M. Berman, "A Critical Review of Recent Large-Scale Experiments on Hydrogen-Air Detonations" (to be published in Nuclear Science and Engineering).

8. H. W. Bertini, "Descriptions of Selected Accidents that have Occurred at Nuclear Reactor Facilities," Nuclear Safety Information Center, ORNL/NSIC-176 (April 1980).

9. V. I. Budnikov, et al., "Stability of the Radial and Azimuthal Energy Distribution in a Boiling-Water Reactor," Atomnaya Energiya 45 (5), 331-335 (1978) (translation).

10. A. L. Camp, et al., "Light Water Reactor Hydrogen Manual," NUREG/CR-2726, SAND82-1137, Sandia National Laboratories and General Physics Corporation (1983).

11. A. L. Camp, et al., "HECTR Version 1.0 User's Manual," NUREG/CR-3913, SAND84-1522, Sandia National Laboratories (1985).

12. Yu. M. Cherkashov, et al., "Mathematical and Experimental Study of Emergency Cooling of RBMK-1500 Reactor in Case of Maximum Credible Accident," Russian 4, 23-33 (1981) (translation).

13. V. M. Chernyshenko, "Construction Parameters for Chernobylskaya AES Given," Russian 11, 2-6 (1984) (translation).

14. H. H. Chung and G. R. Thomas, "Zircaloy-Oxidation and Hydrogen-Generation Rates in Degraded-Core Accident Situations." (No date or publisher available.)

15. Testimony of Thomas B. Cochran, Ph.D., on behalf of the National Resources Defense Council, Inc., before the Subcommittee on Energy Conservation and Power of the Committee on Energy and Commerce, US House of Representatives, May 7, 1986.

16. Crawford Report
    a. "A Safety Assessment of DOE Nuclear Reactors," DOE/US-0005, March 1981.
    b. Merson Booth, et al., "Safety Overview and Management Function," DOE/US-0006, February 1981.
    c. "Action Plan in Response to March 1981 Report to NFPQT Committee," DOE/US-0007, March 1981.
    d. "Procedures, Operations, and Maintenance," DOE/US-0008, February 1981.

17. M. K. De, "Steam Carbon Reactions, Fort St. Vrain FSAR," US Nuclear Regulatory Commission paper. (No date available.)

18. L. Devell, et al., "Initial Observations of Fallout at Studsvik from the Reactor Accident at Chernobyl," The Safety Board of the Swedish Utilities RKS. (No date available.)

19. Edward O. Dietrich, "An Independent On-Site Safety Assessment of the N-Reactor Operation," UNC Nuclear Industries, Inc. (1983).

20. N. A. Dollezhal', et al., "Design of the RBMK-1000 Reactor," presented at Risley under the SCUAE/UKAEA Agreement for Exchanges of Information on Pressure Tube Reactors, February 1977.

21. N. A. Dollezhal' and I. Ya. Yemel'yanov, "Physical Characteristics of the Core," in Channel Nuclear Energy Reactor (Foreign Broadcast Information Service, 1981), Chap. 2, pp. 11-47.

22. N. A. Dollezhal' and I. Ya. Yemel'yanov, "Design of a Reactor Plant," in Channel Nuclear Energy Reactor (Foreign Broadcast Information Service, 1981), Chap. 3, pp. 48-79.

23. N. A. Dollezhal' and I. Ya. Yemel'yanov, "Channel-Type Nuclear Power Reactor," in Channel Nuclear Energy Reactor (Foreign Broadcast Information Service, 1981), Chap. 5, pp. 95-101.

24. N. A. Dollezhal' and I. Ya. Yemel'yanov, "The Recharging Machine," in Channel Nuclear Energy Reactor (Foreign Broadcast Information Service, 1981), Chap. 10, pp. 182-188.

25. N. A. Dollezhal' and I. Ya. Yemel'yanov, "Prospects for Development of Uranium-Graphite Channel-Type Reactors," in Channel Nuclear Energy Reactor (Foreign Broadcast Information Service, 1981), Chap. 11, pp. 189-203.

26. N. A. Dollezhal' and I. Ya. Yemel'yanov, "Means of Control," in Channel Nuclear Energy Reactor (Foreign Broadcast Information Service, 1981), Chap. 6, pp. 96-137.

27. N. A. Dollezhal' and I. Ya. Yemel'yanov, "Study of Safety Problems," in Channel Nuclear Energy Reactor (Foreign Broadcast Information Service, 1981), Chap. 9, pp. 140-181.

28. N. A. Dollezhal', "Graphite-Water Steam-Generating Reactor in the USSR," Nucl. Energy 20, 385-390 (1981).

29. N. A. Dollezhal', "Nuclear Power and the Scientific-Technical Problems in its Development," Atomnaya Energiya 44 (3), 203-212 (1978) (translation).

30. N. A. Dollezhal', et al., "Some Characteristics of and Experience with the Operation of Nuclear Power Plants with RBMK-1000 High-Powered Water-Cooled Channel Reactors," Atomnaya Energiya 54 (4), 257-262 (1983) (translation).

31. N. A. Dollezhal' and I. Ya. Emel'yanov, "Experience in the Construction of Large Power Reactors in the USSR," Atomnaya Energiya 40 (2), 117-126 (1976) (translation).

32. V. Dubrovsky, "Construction of Nuclear Power Plants" (Mir Publishers, Moscow, A. Kuznetsov, translation). (No date available.)

33. F. J. Edeskuty, et al., "Safety Aspects of Large-Scale Combustion of Hydrogen," presented at the 6th World Hydrogen Energy Conference, Vienna, Austria, July 20-24, 1986.

34. W. A. Emel, US DOE Compilation, "Chernobyl Data" (May 20, 1986).

35. I. Ya. Emel'yanov, et al., "Physical Startup of the RBMK-Reactor of the Second Unit of the V. I. Lenin Nuclear Power Station, Leningrad," Atomnaya Energiya 40 (2), 127-132 (1976) (translation).

36. I. Ya. Emel'yanov, et al., "Safety of Power Plants with Boiling-Water Graphite Channel Reactors," Atomnaya Energiya 43 (6), 458-464 (1977) (translation).

37. I. Ya. Emel'yanov, et al., "Increasing the Efficiency of Uranium Utilization in the RBMK-1000 Reactor," Atomnaya Energiya 46 (3), 139-141 (1979) (translation).

38. I. Ya. Emel'yanov, et al., "Design Provisions for Operational Capability of a Nuclear Power Plant with a High-Powered Water-Cooled Channel Reactor in Emergency Regimes," Atomnaya Energiya 50 (4), 251-254 (1981) (translation).

39. I. Ya. Emel'yanov, et al., "Power Distribution Monitoring and Control for a RBMK Reactor," Atomnaya Energiya 48 (6), 360-365 (1980) (translation).

40. EPRI viewgraphs, "Soviet Nuclear Power Program." (No author or date available.)

41. Anson Franklin, "U. S. Reactor Safety," Director of Communications memo to Donald Clarey, White House Cabinet Affairs (April 29, 1986).

42. Haruo Fujii, Ed., Directory of Nuclear Power Plants in the World (Japan Nuclear-Energy Information Center Co., Ltd., Tokyo, Japan, 1985).

43. GAO Report B-222195 to Ranking Minority Member, Subcommittee on Energy, Nuclear Proliferation, and Government Processes, Committee on Governmental Affairs, United States Senate, "Safety Analysis Reviews for DOE's Defense Facilities Can Be Improved," June 16, 1986, J. Dexter Peach, Director.

44. "General Safety Regulations of Nuclear Power Plants During Design, Construction and Operation (OPB-82)," Atomnaya Energiya 54 (2) 151-160 (1983) (translation).

45. T. Keith Glennan, "Report of the New Production Reactor Concept and Site Selection Advisory Panel," letter to The Honorable Donald P. Hodel, Secretary, US Department of Energy (November 15, 1982).

46. John Greenwald, "Deadly Meltdown," Time, May 12, 1986, pp. 39-52.

47. E. Hanrahan, "Summary of Reported Field Office Assistance Efforts Related to Chernobyl," DOE May 13, 1986.

48. R. K. Hilliard, et al., "Removal of Iodine and Particles by Sprays in the Containment Systems Experiment," Nuclear Technology 10, 499-519 (1971).

49. "Hydrogen Behaviour and Control and Related Containment Loading Aspects," Proceedings of a Specialists' Meeting Organized by the International Atomic Energy Agency, Suzdal, USSR (September 19-23, 1983).

50. IPSN Report N^{o} 2/86, "The Chernobyl Accident, Revision 2" (Commissariat A L'Energie Atomique Institut de Protection et de Surete Nucleaire, June 1986).

51. J. R. Ireland, "Zirconium Content Comparisons for Chernobyl-4, N-Reactor, and a Commercial BWR," Los Alamos National Laboratory document Q-DO/TR-86-63 (June 5, 1986).

52. J. R. Ireland, "Hydrogen Generation Potential for Chernobyl-4, N-Reactor, and Typical US Commercial Plants," Los Alamos National Laboratory document Q-DO/TR-86-72 (June 24, 1986).

53. J. R. Ireland, "Adiabatic Heatup-Rate Comparisons for Chernobyl-4, N-Reactor, BWR-6, AND TMI-2," Los Alamos National Laboratory document Q-DO/TR-86-74 (June 26, 1986).

54. J. R. Ireland, "Energy Potential Comparisons for Chernobyl-4, N-Reactor, AND TMI-2," Los Alamos National Laboratory document Q-DO/TR-86-75 (June 27, 1986).

55. J. R. Ireland, "Graphite Thermal-Diffusion Time in N-Reactor from GSCS to Pressure Tubes," Los Alamos National Laboratory document Q-DO/TR-86-87 (July 23, 1986).

56. N. V. Isayev, et al., "Unloading Surplus Absorbers from RBMK-1000 Core," Atomnaya Energiya 56 (5) 280-282 (1983) (translation).

57. Mikael Jensen and John-Christer Lindhe, "Activities of the Swedish Authorities Following the Fallout from the Soviet Chernobyl Reactor Accident," National Institute of Radiation Protection, 1986-05-12 (1986).

58. L. P. Kabanov, "Effectiveness of Emergency Cooling of Water-Cooled Power Reactors," Thermal Engineering 30 (2), 61-67 (1983) (translation).

59. P. M. Kamanin, et al., "Measurements of Spectral Indices in Uniform RBMK Reactor Lattices for Various Channel to Graphite Temperature Gradients," Russian 50 (3), 176-181 (1979) (translation).

60. P. Karahalios, "Group of Experts on Accident Consequences, Special Meeting on Chernobyl, Paris, France," Stone and Webster Engineering Corporation memorandum 52202.36 to R. Gardner (June 20, 1986).

61. V. B. Karasev, et al., "Operating Efficiency of Steam Separators in Power Plants with RBMK Reactors," Atomnaya Energiya 53 (2), 70-74 (1982) (translation).

62. A. Klimov, Nuclear Physics and Nuclear Reactors, MIR Publishers, Moscow, USSR. Translated from the Russian by O. Rudnitskaya.

63. V. S. Knoviz and L. V. Golubkov, "Chernobyl'skaya AES Third Phase Construction Begins," Russian 1, 19-23 (1984) (translation).

64. O. M. Kovalevich, A. N. Isaev, and O. A. Pavlovskii, "Possible Criterion for Additional Safety Requirements for Nuclear Stations Sited Near Large Cities," Atomnaya Energiya 51 (1), 41-44 (1981) (translation).

65. N. I. Kozlov, et al., Compilers, "Nuclear Safety Regulations for Nuclear Electric Power Plants (AES)" State Committee for Use of Atomic Energy USSR and State Nuclear Safety Inspection, USSR, 25 pages.

66. E. V. Kulikov, "State-of-the-Art and Development Prospects for Nuclear Power Stations Containing RBMK Reactors," Atomnaya Energiya 56 (6), 359-365 (1984) (translation).

67. C. P. Kupiec and A. L. Camp, "Hydrogen Behavior and Control at Light Water Reactors During Normal Operations and During Accidents." (No publisher or date available.)

68. J. LaFleur and V. Stello, "Visit to Leningrad Power Station," trip report, February 11, 1978, US Nuclear Regulatory Commission (SECY-78-11B).

69. Ye. M. Levin and M. G. Kremen', "Particulars of Startup, Adjustment on Third Generating Unit of Chernobyl AES," Russian 6, 50-54, (1983) (translation).

70. Roy A. Haarman, "Los Alamos Information," Los Alamos National Laboratory document Q-6/86-615 (May 14, 1986).
    a. Introduction to N-Reactor
    b. Selected Replacement N-Reactor (RNR) Viewgraphs (from 1982 Glennan Committee)
    c. N-Reactor Updated Safety Analysis Report, United Nuclear Industries, Inc., UNI-M-90, February 28, 1978.
    d. N-Reactor Plant Manual, Vol. 1, United Nuclear Industries, Inc., UNI-M-94, June 15, 1982.
    e. Bibliography of N-Reactor Reports

71. Los Alamos Scientific Laboratory report "Hydrogen Safety and Environmental Control Assessment," Final Report, November 1976-September 1979.

72. N. F. Lukonin, "The Leningrad AES Imeni V. I. Lenin," Atomnaya Energiya 48 (4), 220-223 (1980) (translation).

73. V. P. Manno and M. W. Golay, "Hydrogen Transport in Containments: A Survey of Analytical Tools and Benchmark Experiments," Nuclear Safety 25 (6), 797-814 (1984).

74. C. Rogers McCullough, "The Windscale Incident," in "Proceedings of the 1958 Atomic Energy Commission," TID-7569 (1958).

75. Ye. P. Markov, et al., "Emergency Localization System at Third Unit of Chernobyl AES," Russian 1, 61-63 (1984) (translation).

76. Walter Mitchell, III, P.E., "Design Features of the Soviet RBMK-1000/Chernobyl-4 Reactor," prepared for ACRS (May 4, 1986).

77. Yu. I. Mityaev and V. K. Vikulov, "Cassette Permutation to Equalize the Energy Distribution and Improve the Fuel Cycle of the RBMK Reactor," Atomnaya Energiya, 52 (4), 231-235 (1982) (translation).

78. Motor Columbus, Accident at the Chernobyl Plant: Description of the Plant, Review of Reported Events, Accident Scenarios and Initial Comparison with LWR Designs (Consulting Engineers, Inc., Baden, Switzerland, June 1986).

79. National Nuclear Corporation Limited, The Russian Graphite Moderated Channel Tube Reactor (Booths Hall, Knutsford, Cheshire, UK, May 1986).

80. A. S. Neuls, et al., "Independent Safety Review of the Savannah River Production Reactors," Los Alamos National Laboratory FY 1984 Progress Report (January 1986).

81. R. E. Nightingale, Ed., Nuclear Graphite, Hanford Laboratories, General Electric Co.

82. N-Reactor Updated Safety Analysis Report, UNI-M-90, February 1978.

83. O. Yu. Novosel'skii, et al., "Tests on Improved Steam Separators in the Third Unit at the Chernobyl Nuclear Power Station," Atomnaya Energiya 57 (6), 382-385 (1984) (translation).

84. Nuclear Safety Board of the Swedish Utilities (RKS), Accident Report, Extensive Core Damage and Graphite Fire (May 28, 1986) (translation).

85. Original Safety Analysis, "N-Reactor Hazards Summary Report," 6 Volumes (1963). (No publisher available.)

86. A. M. Petrosyants, "Problems of Nuclear Science and Technology." (No publisher or date available.)

87. A. M. Petrosyants, "Nuclear Power in the Soviet Union," in Scientific Search to Atomic Industry, THE INTERSTATE, Chap. 4 (1976).

88. A. M. Petrosyants, "Nuclear Energy, Man and the Environment," Science in the USSR 3 (1982).

89. P. A. Platonov, et al., "Degree of Perfection of Graphite and Changes in its Properties Under Irradiation," Atomnaya Energiya 46 (4), 248-254 (1979) (translation).

90. K. R. Price, "Environmental Monitoring at Hanford for 1984," Pacific Northwest Laboratory report PNL-5407 (May 1985).

91. V. I. Pushkarev, et al., "Ways of Altering the Coefficients of Reactivity in RBMK Reactors," Atomnaya Energiya 46 (6), 386-389 (1979) (translation).

92. N. G. Rassohin, "Emergency Cooling Heat Transfer Problem of Nuclear Reactors," Abstract, Moscow Power Engineering Institute, USSR.

93. D. L. Reid, et al., "Interim Report: The Metal-Water Reactions of Irradiated N-Reactor Fuels at 1025 to 1080°C," Battelle Memorial Institute, Pacific Northwest Laboratories, BNWL-1361 (1970).

94. V. S. Romanenko, "Survey of Neutron-Physics on the RBMK-1000 Reactor," presented at Risley under the SCUAE/UKAEA Agreement for Exchanges of Information on Pressure Tube Reactors, February 1977.

95. V. S. Romanenko and A. V. Krayushkin, "Physical Characteristics of an RBMK Reactor in the Transitional Period," Atomnaya Energiya 53 (6), 367-373 (1982) (translation).

96. Testimony of Joseph F. Salgado, Under Secretary, US DOE, before the Energy and Water Appropriations Subcommittee on Nuclear Safety, US House of Representatives, May 6, 1986.

97. V. M. Sedov, et al., "Chemical-Technological Modes during Startup and Initial Operating Period of AES using RBMK Reactor," Russian 12, 9-10 (1981) (translation).

98. B. A. Semenov, "Nuclear Power in the Soviet Union," IAEA Bulletin 25 (2) 47-48. (No date available.)

99. V. A. Sidorenko, et al., "Basic Approaches to Nuclear Power Station Safety in the USSR," Atomnaya Energiya 43 (5), 360-365 (1977) (translation).

100. V. A. Sidorenko, et al., "Nuclear Electric Power Station Safety," Russian 1, 6-10 (1978) (translation).

101. A. P. Sirotkin, "Conference on the Fifth Anniversary of the Commissioning of Leningrad Nuclear Power Station," Atomnaya Energiya, 46 (5) 364-365 (1979) (translation).

102. V. N. Smolin, V. I. Esikov, V. P. Shishov, V. P. Vasilevskii, and V. S. Grigor'ev, "Safety Under Servicing Cooling Conditions for RBMK Reactors," Atomnaya Energiya 57 (2), 87-91 (1984) (translation).

103. V. P. Smolin, et al., "An Experimental Study of Emergency Cooling Conditions in RBMK Reactors on Load Disconnection," Atomnaya Energiya 57 (2), 83-87 (1984) (translation).

104. V. P. Smolin, et al., "Study of Safety of Cooling Modes for Repairs on Graphite-Moderated, Water-Cooled Channel Type Power Reactors," Russian 57 (2), 87-91 (1984) (translation).

105. J. W. Spore, "Analysis of Russian Fuel Bundle Hydrodynamics and Heat Transfer Based on Available Data," Los Alamos National Laboratory document Q-DO/TR-86-78 (July 2, 1986).

106. State Committee for Using the Atomic Energy of USSR, "The Accident at the Chernobyl AES and Its Consequences," Data prepared for the International Atomic Energy Agency Expert Conference, August 25-29, 1986, Vienna, Austria (translated from the Russian for the Department of Energy, August 17, 1986).

107. TASS Reports on Chernobyl Nuclear Accident. (No date available.)

108. B. Thomas, "The Chernobyl Accident," Seminar on Operating Procedures for Abnormal Conditions in Nuclear Power Plants, Munich, Germany, June 23-27, 1986.

109. M. Tokar, "Reactor Fuel Melt Incidents," letter to R. O. Meyer, US NRC (August 7, 1979).

110. L. I. Turetskiy, et al., "Accident Localization System of Energy Units with RBMK-1000 Reactor," Russian 2, 14-19 (1984) (translation).

111. USSR State Committee on the Utilization of Atomic Energy, "The Accident at the Chernobyl Nuclear Power Plant and Its Consequences," information compiled for the IAEA Experts Meeting, August 25-29, 1986, Vienna, Austria (August 1986).

112. USSR State Committee on the Utilization of Atomic Energy, "Post Accident Review Meeting Slides," viewgraphs (translated) presented at the IAEA Experts Meeting, August 25-29, 1986, Vienna, Austria (August 1986).

113. UNC Nuclear Industries, "Fuel Cladding Failures & Primary Cooling System Debris," Briefing Book. (No date available.)

114. UNC Nuclear Industries, "Small Light Water Graphite Reactor Preconceptual Design Report," UNI-3750, Vol. 1: Plant Description, Vol. 3: Supporting Documentation (December 1985).

115. United Nuclear Corporation report, "Performance Monitoring Management Information," published by Reactor Administration and Control, (May 1978).

116. US Department of Energy, "Reactor Safety--N-Reactor vs Chernobyl Comparisons," Response to Bevill questions.

117. US Department of Energy, "Environmental Protection, Safety, and Health Protection Program for DOE Operations," DOE Order 5480.1A (August 13, 1981).

118. US Department of Energy, "Environmental Protection, Safety, and Health Protection Standards," DOE Order 5480.4 (May 15, 1984).

119. US Department of Energy, Richland Operations Office Report, "Emergency Plan" (April 1985).

120. US Department of Energy Report, "Performance Objectives and Criteria for Technical Safety Appraisals" (May 1986).

121. US Department of Energy, "Report of the Special Safety Team Review of N-Reactor (Graphite and Confinement Issues)" (May 1986).

122. US Department of Energy Report, "Technical Safety Appraisal of the N-Reactor" (June 1986).

123. US Department of Energy Report, "Design Review of N-Reactor" (July 1986).

124. United States General Accounting Office, "Briefing Report to Congressional Requesters, Nuclear Safety: Comparison of DOE's Hanford N-Reactor with the Chernobyl Reactor," (August 1986).

125. US Nuclear Regulatory Commission and the Electric Power Research Institute, Hydrogen and Water Reactor Safety (Proc. of the Second International Conference on the Impact of Hydrogen on Water Reactor Safety, Albuquerque, NM, October 3-7, 1982).

126. US Nuclear Regulatory Commission, Division of Safety Review and Oversight, Office of NRR, "Status Briefing on the Chernobyl Nuclear Accident," presented to the ACRS, May 8, 1986.

127. The United States of America Nuclear Power Reactor Delegation Visit to the Union of Soviet Socialist Republics, "Soviet Power Reactors," ERDA-2, (1974).

128. A. M. Usik, et al., "Installation of the Reactor Section Equipment," Russian 12, 8-11 (1984) (translation).

129. I. A. Varovin, et al., "Experience in 10 Years of Operating Channel-Type Nuclear Reactor Recounted," Atomnaya Energiya 55 (6), 349-353 (1983) (translation).

130. Yu. S. Virgil'ev, "Thermal Expansion of Structural Graphite and the Effect of Neutron Irradiation," Atomnaya Energiya 47 (5), 305-308 (1979) (translation).

131. L. M. Voronin, "Nuclear Power Generating Units with RBMK-1000 Reactors Described, Evaluated," Russian 1, 10-15 (1979) (translation).

132. L. M. Voronin, "Operation and Maintenance of Nuclear Power Plants," Russian, 7-47 (1981). (Volume number not available.)

133. Testimony of Mary L. Walker, Assistant Secretary for ES&H, US DOE, before the Subcommittee on Energy Conservation and Power of the Committee on Energy and Commerce, US House of Representatives, May 7, 1986.

134. I. Ya. Yemel'yanov, S. P. Kuznetsov, Yu. M. Cherkashov, "Design Measures to Ensure Operability of Nuclear Electric Plants with RBMK Reactors Under Emergency Conditions," Atomnaya Energiya 50 (4), 251-254 (1980) (translation).

135. I. Ya. Yemel'yanov, A. N. Alexsakov, V. P. Vasilevskiy, "Study of Operating Conditions of Power Generating Unit with RBMK Reactor with False Turning On of Reactor's Emergency Cooling System," Russian 3, 10-13 (1984) (translation).

136. A. P. Yeperin, "Performance of Leningrad Nuclear Electric Power Station Reviewed," Russian 8, 6-9 (1981) (translation).

137. N. I. Zhizn, "Design and Operation of Large Nuclear Power Reactors Discussed," Russian 11, 44-52 (1980) (translation).

1st Joint Briefing
May 22-23, 1986
DOE--Forrestal Building
Washington, DC

Consultants Present: Roddis, Tape, Pigford, Lewis, Leverett

Speaker	Title & Organization	Subject
E. Hanrahan	Special Assistant to the Under Secretary (DOE)	EPA Task Force on Chernobyl
D. Bunch	Deputy Assistant Secretary for Nuclear Energy, DOE	Chernobyl Accident
M. Walker	Assistant Secretary for ES&H, DOE	DOE Reviews of N-Reactor
G. Oertel, N. Klug	Deputy Assistant Secretary for Safety, Health & Q.A., DOE Team Leader for N-Reactor Special Safety Review, DOE	Quick Response Safety Review of N-Reactor in Light of Chernobyl
C. Simpson, J. Ford	Director of Office of Nuclear Materials Production, DOE Office of Nuclear Materials Production, DOE	N-Reactor Safety Programs
J. Salgado, S. Foley, M. Walker, A. Trivelpiece, E. Hanrahan	Under Secretary, DOE Assistant Secretary for Defense Programs, DOE Assistant Secretary for ES&H, DOE Assistant Secretary for Energy Research, DOE Special Assistant to the Under Secretary, DOE	Briefing to Consultants on DOE Issues Concerning Chernobyl and N-Reactor

Appendix 3 page 2.

2nd Joint Briefing
June 12-13, 1986
DOE--Forrestal Building
Washington, DC

Consultants Present: Roddis, Tape, Pigford, Lewis

Speaker	Title & Organization	Subject
T. Johnson,	Vice President, GA Technologies	Chernobyl Accident Sequence
A. Baxter	Engineer, GA Technologies	
L. Dodd	Manager, Advanced Energy Concepts PNL	Chernobyl Accident
R. Laney	Independent Consultant and former Deputy Director for ANL	Leningrad AES Visit
J. Meinhardt,	Deputy Assistant Secretary for Nuclear Materials, DOE	N-Reactor Safety Issues & Safety Analyses
C. Simpson,	Director of Office of Nuclear Materials Production, DOE	
J. Ford,	Office of Nuclear Materials Production, DOE	
E. Goldberg,	Deputy Manager, RLO, DOE	
L. Leach,	Vice President, Programs & Planning UNC	
G. Smith	Manager, Technology Division, UNC	
V. Stello	Executive Director for Operations, NRC	NRC Response to Chernobyl Accident
M. Walker,	Assistant Secretary for ES&H, DOE	Status Report on N-Reactor Design Review and Technical Safety Appraisal Reports
H. Field,	Team Leader, Technical Safety Appraisal Team, DOE	
G. Smithwick,	Deputy Assistant Secretary for Environment, DOE	
H. Kouts	Chairman, Department of Nuclear Energy, BNL	May 1986 Meeting on Chernobyl Current Findings
---	---	Classified Briefing
---	---	Classified Briefing

Appendix 3 page 3.

3rd Joint Briefing
June 30-July 2, 1986
Richland, Washington

Consultants Present: Roddis, Tape, Pigford, Lewis, Wilkinson, Leverett

Speaker	Title & Organization	Subject
M. Lawrence	Manager, RLO	Introduction
G. Elderkin,	Program Manager, Atmospheric Sciences Program, PNL	PNL Briefings on Chernobyl Accident
L. Dodd,	Manager, Advanced Energy Concepts, PNL	
W. Little,	Staff Member, PNL	
L. Pederson	Staff Member, PNL	
L. Leach,	Vice President, Programs & Planning, UNC	N-Reactor Plant Tours* (entire reactor site, training simulator, and Zone-1)
M. Payne,	Director, N-Reactor Plant, UNC	
R. Pyzel,	Program Director, UNC	
D. Watson	Simulator Operations, UNC	
G. Smith,	Manager, Technology Division, UNC	Evaluation of Hydrogen Burns
L. Muhlestein	Westinghouse Hanford Company	
R. Hobbins	Consultant, Department of Nuclear Reactor Research and Technology EG&G Idaho	Hydrogen Generation Issue
J. Schmidt	Program Director, Productivity Retention, UNC	Confinement Pressure Capability
H. Toffer	Manager, Advanced Technology & Physics, UNC	Fission Product Release and Short Period Event
N. Miller	Technical Assistant to the President, UNC	Anticipated Transient without Scram
P. Carlson	Manager, Safety Assessment & Analysis Section, UNC	Common Mode Failures
J. Kelly	Manager, Preliminary Engineering UNC	Safe Shutdown from Safe, Remote Location
L. Leach	Vice President, Programs & Planning, UNC	Production Assurance Program
R. Barber	Director of Nuclear Safety, DOE	ES&H Design Review of N-Reactor

---

*For the Zone 1 tour, consultants attended a one-hour Radiation Safety Indoctrination course, suited up, and then toured front/back/top faces of reactor.

R. Henry	Consultant, Fauske & Associates	Accident Analyses for N-Reactor
L. Ybarrando	President, Ybarrando & Associates	Design Performance for N-Reactor
H. Field	Team Leader, Technical Safety Appraisal Team, DOE	N-Reactor Technical Safety Appraisal
P. Turner,	RLO Emergency Preparedness Coordinator, DOE	Emergency Preparedness
F. Galegar	Manager, Emergency Planning, UNC	
M. Lawrence	Manager, RLO	Exit Interview with Roddis, Lewis

4th Joint Briefing
July 14-16, 1986
Los Alamos, New Mexico

Consultants Present: Roddis, Tape, Pigford, Lewis, Wilkinson, Leverett

Speaker	Title & Organization	Subject
T. Hirons	Energy Division Leader, LANL	Introduction
J. Taylor	Staff Member, ORG 311, SNL	Chernobyl Sequence of Events
R. Haarman,	Safety Assessment Group Leader, Q-6, LANL	N-Reactor PRA Status and Safety Review Work
D. Stack	Staff Member, Safety Assessment Group, Q-6, LANL	
T. Suchocki	Staff Member, Safety Assessment Group, Q-6, LANL	Savannah River PRA Conclusions
P. Sciacca	Consultant, Science & Engineering Associates	CONTAIN Code Models
D. Smith,	Chief, Nuclear & Facility Safety RLO, DOE	Unusual Occurrence Events at N-Reactor
N. Miller	Technical Assistant to the President, UNC	
---	---	Classified Briefing
---	---	Classified Briefing

Appendix 3 page 6.

5th Joint Briefing
September 3-4, 1986
DOE--Forrestal Building
Washington, DC

Consultants Present: Roddis, Tape, Pigford, Lewis, Wilkinson (present on September 3), Leverett

Speaker	Title & Organization	Subject
M. Walker	Assistant Secretary for ES&H, DOE	Status of ES&H Reports on N-Reactor
D. Bunch	Deputy Assistant Secretary for Nuclear Energy, DOE	IAEA Vienna Meeting on Chernobyl Accident, August 25-29, 1986
A. Trivelpiece	Assistant Secretary for Energy Research, DOE	DOE Response to Information Requested by Consultants on July 18, 1986
S. Foley,	Assistant Secretary for Defense Programs, DOE	Status of Action Plan for N-Reactor
A. Trivelpiece	Assistant Secretary for Energy Research, DOE	

Appendix 4 page 1.

Special Appointment
August 1, 1986
DOE-Forrestal Building
Washington, DC

SUBJECT: Request for Additional Information

Consultants Present: Roddis, Tape, Wilkinson

DOE Representatives Present:

J. Salgado, Under Secretary, DOE

M. Walker, Assistant Secretary for ES&H, DOE

A. Trivelpiece, Assistant Secretary for Energy Research, DOE

J. Gilbert, Executive Assistant to the Assistant Secretary for Defense Programs, DOE

E. Hanrahan, Special Assistant to the Under Secretary (DOE)

Appendix 4 page 2.

Special Appointment
May 6, 1986
DOE-Forrestal Building
Washington, DC

SUBJECT: Meeting to Define Charter of Consultant Review Group

Consultants Present: Roddis, Tape

DOE Representatives Present:

J. Salgado, Under Secretary, DOE

M. Walker, Assistant Secretary for ES&H, DOE

A. Trivelpiece, Assistant Secretary for Energy Research, DOE

S. Foley, Assistant Secretary for Defense Programs, DOE

Appendix 4 page 3.

Special Meeting
June 20, 1986
DOE-Forrestal Building
Washington, DC

SUBJECT: Chernobyl Briefing for DOE by M. Rosen, Director of Nuclear Safety, IAEA

Consultants Present: Roddis, Tape

N-REACTOR AND TYPICAL RBMK-1000 COMPARISONS

A. Overall Design Characteristics	N-Reactor	RBMK-1000
Reactor type	Horizontal pressure tube-pressurized water-graphite moderated	Vertical pressure tube-boiling water-graphite moderated
Design power generation (MWt)	4080	3140
Electrical power generation (MWe)	860	1000
Inlet temperature (avg. °F)	400	518
Outlet temperature (avg. °F)	543	543
Average steam quality at core exit (%)	0.0	14.5
Operating pressure (outlet psia)	1600	1037
Total reactor coolant flowrate (lb/h)	83.2×10^6	82.5×10^6
Total number of pressure tubes	1003	1693
Lattice spacing	9 in. vertical x 8 in. horizontal	9.8 in. x 9.8 in.
B. Fuel Design		
Design	Tube-in-Tube Annular	Two 3.5 m 18 rod elements in series
Fuel material	U-metal	UO_2
Amount (MT)	365	192
Length (ft.)	34.8	22.96
Orientation	Horizontal	Vertical
Enrichment (%U^{235})	0.7-1.25	1.8-2.0
Average burnup (MWD/MTU)	1000	20,000
Maximum channel power (MW_t)	5.0	3.0
Cladding	Zr-2	Zr/Nb
Pressure tube OD (in.)	3.26	3.46
Pressure tube wall thickness (in.)	0.275	0.157
Pressure tube material	Zr-2	Zr/Nb
C. Moderator Design		
Material	TSX graphite	Graphite
Operating temperature (°F)	932	1292
Amount (MT)	1800	2000

D. Refueling	N-Reactor	RBMK-1000
	During shutdown	On-line
E. Loop Design		
System material	Carbon steel	Austenitic stainless steel
Equipment cells	6	2
Independent flow loops	1	2
Steam drums (total/per loop)	None	4/2
Steam generators (total/normally operating)	12/10	None
Steam pressure (psia)	150	995
Steam flowrate (lb/hr)	14.0×10^6	12.0×10^6
Main coolant pumps (total/normally operating)	6/5	8/6
F. Control-Rod System		
Type	Boron carbide encased in titanium, driven by pressurized accumulators horizontally into reactor.	Boron steel segments encased in aluminum, lowered by gravity and retrieved by servomechanisms from above through a cable.
Number of control assemblies	84	211
Neutron absorption material	Boron in B_4C	Boron steel
Control rod spacing	32 in. horizontal 36 in. vertical	19.7 in. x 19.7 in.
Drive	Hydraulic (with accumulators)	Gravity
Control rod full insertion time (s)	2.5	20

G. Safety Shutdown System	N-Reactor	RBMK-1000
Type	Boron in boron oxide balls contained in hoppers above individual moderator channels. Release is spring loaded and held by electromagnetic system in a "fail-safe" manner.	Same as control rod assemblies
Number of safety shutdown assemblies	107	21
Neutron absorption material	Boron in B_4C	Boron steel
Drive	Gravity	Gravity
H. Radionuclide Release Control System		
Type	Confinement system employing initial steam release from vent valves followed by high efficiency filtration of releases.	Partial steam suppression of releases from the reactor cavity, inlet piping, and pumps in bubbler pond below reactor.
Enclosure	Entire reactor, coolant system and reactor gas system.	Lower half of reactor and lower half of piping system.
Function	Confine radionuclides from the reactor and contaminated piping systems.	Condense steam from pipe break or steam separator relief valves.
Design pressure	+5.0 psig to -2.0 psig	Enclosure areas designed to 58 psia

A final session for joint briefings on the IAEA meeting of August 25, 1986, has been scheduled in Washington, DC for the consultants on September 3-4. At that time, the consultants have requested that information be provided on official DOE positions in two other areas:

(1) Modifications: It has been unclear what the Department's official position is on the following modifications of safety-related systems that are of concern to us:

   a. Addition of an independent, redundant ECCS,
   b. Safety upgrade of the GSCS,
   c. Improvement of control room habitability under accident conditions and addition of remote shutdown capability, and
   d. Containment of radioactive liquids produced under normal operational and accident conditions.

(2) Implementations: There are a number of deficiencies already identified that are unresolved and will be a number of recommendations in the ES&H reports. While we are in Washington in September, we would like to have a coordinated list of the deficiencies and recommendations in order of priority and a copy of the Department's action plan to close on the deficiencies and to implement the recommendations.

Sincerely yours,

Louis H. Roddis, Jr.
Chairman
Panel of Expert Consultants

cy: G. F. Tape
    T. H. Pigford
    M. C. Leverett
    H. W. Lewis
    E. P. Wilkinson
    L. M. Smith, DOE/ER
    J. R. Ireland, LANL

Appendix 6 page 1.

JUL 16 1986

Dr. Alvin W. Trivelpiece
Director
Office of Energy Research, ER-1
US Department of Energy
Washington, DC 20585

Dear Dr. Trivelpiece:

On behalf of the Expert Consultants, I am exercising my position as Administrative Chairman to request additional information concerning the N-Reactor. During the course of both joint and individual briefings, the six consultants have made specific information requests for data extending beyond those presented at the briefings. When this information has been readily available, it has been provided promptly.

There are two areas, however, that are considered critical to N-Reactor safety. Questions have been raised in these areas that remain unanswered either because preparation of the information requested requires substantial commitment of people and dollar resources or has been given a lower priority than the consultants believe is appropriate for the present situation. The information requested is considered essential to the individual consultant evaluations and recommendations for the key N-Reactor safety issues raised by the Chernobyl accident.

(1) Technical area: Information has been requested on the amounts, rates of generation, and potential remedies for evolution of hydrogen under hypothetical conditions at N-Reactor more realistic than those covered in the NUSAR. An evaluation using current calculational methods would provide the information and should include the distribution of hydrogen potentially evolved in the confinement area of N-Reactor Zone 1, and the potential for control of the hydrogen. It is necessary also to include in the evaluation the adequacy of the radioactive removal system in the confinement, the adequacy of venting to relieve pressure before radioactivity is released to the confinement, and the effectiveness of the graphite and shield cooling system (GSCS) in reducing metal-water reactions during rapid transients.

(2) Operations area: During the joint briefings at Richland, Washington, and the tour of the N-Reactor, questions on operational issues related to safety were raised that were based on INPO criteria and the experience of the consultants in commercial and military nuclear programs. The issues concern training, interfaces, and emergency preparedness, among others. With the constraints of time on UNC contractor personnel and in order to provide Secretary Herrington with our reports on a timely basis, we believe UNC could take advantage of their participation in INPO to request from the Institute an accelerated evaluation of N-Reactor operations. This evaluation would provide essential information that the consultants need for their reports.

MILES C. LEVERETT

October 3, 1986

The Honorable John L. Herrington, Secretary
US Department of Energy
1000 Independence Avenue, S.W.
Washington, DC 20585

Dear Mr. Secretary:

SUBJECT: REVIEW OF N-REACTOR SAFETY

In accordance with a request from your office, I have carried out a review of the safety of the Hanford N-Reactor. In this review I have had the benefit of briefings by various DOE staff members, of briefings by the N-Reactor personnel, by national laboratory personnel, of voluminous written material pertaining to the N-Reactor and to the Chernobyl-4 Russian reactor and others of that type. I have also had exchanges of views with five other consultants similarly appointed by your authority (these are Mr. L. H. Roddis, Professor H. W. Lewis, Professor T. H. Pigford, Dr. G. F. Tape, and Admiral (Ret.) E. P. Wilkinson). I have, of course, also drawn on my own association with the N-Reactor during the years 1962-1967.

I have also had the benefit of reading reports generated by three DOE review committees:

Report of the Special Safety Team Review of N-Reactor (graphite and confinement issues) May 1986

Technical Safety Appraisal of the N-Reactor, June 1986

Design Review of N-Reactor, July 1986

Finally, I have seen the draft of the action plan to address the recommendations appearing in the three reports just mentioned.

From this considerable body of information I have drawn conclusions which are my own. They are expressed in summary in this letter. In some cases, my conclusions are similar to those appearing in the above-mentioned reports. I hope that my including them in this letter will add emphasis.

My overall conclusion is that the N-Reactor is being operated safely.

15233 Via Pinto Monte Sereno, California 95030 408/395-8432

However, for continued operation I believe that certain improvements are in order to bring the reactor to a level of safety assurance comparable to that required of commercial nuclear power reactors by the Nuclear Regulatory Commission (NRC). These are improvements which are recommended if it is intended to operate the reactor for the next several years. In my opinion, the question of the safety of the reactor in the more distant future is moot, as will be explained below, because I believe that expansion of the graphite stack will make it necessary to remove all or part of it or replace the reactor completely in the next several years.

According to data which have become available in the last several weeks, the graphite stack appears to be expandng vertically at the rate of about 0.8 in. per year. The clearance between the top of the graphite and the lower surface of the thermal shield is now about 2.3 in., suggesting that contact may be expected in about three years. If prompt action is taken to flatten the power in the reactor, and if the reactor power level is lowered, the rate of expansion can be slowed down so as to provide more time, but even with such measures operation beyond the very early 1990s seems unlikely to be feasible without major repairs involving large expenditures and an extended reactor shutdown period. Taking into account the slowness of the budgetary process and other necessary steps, I believe that the time is at hand when it should be decided whether to replace the N-Reactor with another reactor or simply shut it down when the graphite growth reaches its tolerable limit. The plans that I have seen for replacing the graphite seem only marginally feasible, and extension of reactor life beyond that time would also require other fairly expensive and time-consuming actions.

I am making no judgment regarding whether the operation of the N-Reactor should be continued for the short term, or, if it is not continued, whether a replacement for it should be obtained. Such a judgment would involve matters of national security and others which are beyond any special expertise which I may have. I do believe that operation of the reactor beyond the limit imposed by the growth of the graphite stack would require such extensive upgrading and renovation of the whole plant and the reactor itself as to be cost-ineffective in terms of funds and technical talent.

The fact that the end of N-Reactor's productive life is in sight is, however, no reason for not proceeding expeditiously to make the improvements mentioned above, and which I shall briefly describe below. The N-Reactor went through a period in the 1970s during which the uncertainty regarding its continued operation had the unfortunate effect of allowing the reactor's safety aspects to fall behind the various advances made in the safety of commercial reactors and the changes in NRC requirements. That should not be allowed to happen again. In the period since the 1970s the safety of the N-Reactor has been improved in many ways. As a result it is now safer than before. But there are still areas where improvement is needed in the light of present safety thinking and public perceptions. In the following paragraphs I will elaborate some of these thoughts and summarize my recommendations.

In making judgments regarding reactor safety, my main frame of reference is my association over the last three decades with the safety of commercial nuclear power plants. I believe that the commercial plants constitute a suitable yard stick by which to evaluate the safety of military production reactors.

1. Continued N-Reactor Operation is Acceptable for the Next Several Years

The N-Reactor record of 23 years of operation with no events which have adversely affected public or occupational safety is impressive. It is true that there is no assurance that this situation will continue, but with the intensified attention to safety, which I believe it reasonable to anticipate, I have little concern about operation until such time as the graphite expansion forces complete replacement or shutdown of the reactor.

2. Backup Emergency Core Cooling Project Should Be Completed

I distinguish two kinds of safety precautions: those which tend to prevent accidents, and those which tend to mitigate the effects of an accident once it has started. It is clearly more desirable to prevent accidents than to mitigate them, but both types of precautions are necessary.

My assessment is that the N-Reactor is well supplied with preventive measures. Some of them, like the two, diverse, fast acting reactor shutdown systems and the individual tube flow and cladding failure detectors are unique. I do have some concern about one feature of the emergency core cooling system. This system is made up of two separate systems, either of which is capable by itself of cooling the shutdown reactor. Although the arrangement and protective features of these systems meet the main NRC requirements for independence and fire protection, they are relatively close together in some important areas. This closeness leads to some vulnerability to common cause failure.

I understand that a project to provide a third source of supply of water to the emergency core cooling system, entirely separate from the others, is in an early stage. Even though this system would use existing equipment that does not meet current NRC safety requirements, I recommend strongly that this project be completed expeditiously. I think that this action will complete the provision of an array of core damage preventive measures that will be adequate for the next few years. I note that action on a longer term, higher-quality project of this type has been recommended. That would be appropriate if operation beyond the next few years were planned.

3. Hydrogen Igniters Should Be Installed

The most important mitigative measure at the N-Reactor is the confinement system. The confinement principle is sound and is used in assessing the safety of commercial reactors in certain hypothetical reactor accidents. However, the N-Reactor confinement system suffers from a major uncertainty in that it is not clear that it could withstand an internal explosion of the hydrogen which might be generated in the reactor in a severe accident and released to the confiner.

It is believed that at both Three Mile Island Unit 2 (TMI-2) and at Chernobyl-4 there were hydrogen explosions. In neither case was a major hydrogen explosion considered in pre-accident analyses. The TMI-2 explosion was relatively harmless thanks to a strong containment. At Chernobyl-4 it is now believed that the initial explosion was due to a rapid over-pressurization of the process channels but that subsequent hydrogen combustion contributed importantly to the disastrous nature of the accident because no correct assessment of the magnitude of potential accidents had been made and because no proper provision for accommodating such accidents had been made.

Predictions of the quantity of hydrogen which would be expected in a severe accident in the N-Reactor have been made; relatively small quantities have been predicted. These predictions are controversial because they do not appear to account adequately for some more severe hypothetical (but still mechanistic) accidents. Further remarks on the need for more complete accident identification appear in a later portion of this report. For the present, it may be noted that a large hydrogen explosion in one of the many compartments of the N-Reactor confinement would cause serious damage to it and probably would render it functionally ineffective.

My conclusion is that it is important to provide the N-Reactor with a means of preventing hydrogen explosions or of mitigating their effect to such a degree that the confiner will retain its integrity. I believe that the most practical way of doing this is to install a so-called "distributed ignition system" which will, in effect, ignite the hydrogen as it emerges into the confiner. A series of small pressure pulses, well within the pressure capability of the confiner, rather than one or a few large ones would be the result. The heat of combustion would largely be taken up by the confiner walls, or by the fog spray if operating. Such systems are now required by the NRC in commercial reactors having ice condenser or Mark III types of containment. These types of containment have relatively low design pressure capabilities and would probably be severely damaged by the explosion of the accumulated hydrogen from a severe core accident.

Hydrogen ignition systems are also used in certain reactors of the CANDU type.

I recommend strongly that the design and installation of a distributed hydrogen ignition system be undertaken in the N-Reactor.

4. Probabilistic Risk Analysis Should Be Expedited

I understand that two probabilistic risk analyses are under way, one sponsored by the DOE and the other by the N-Reactor contractor. It is unfortunate that it has taken so long to get a PRA started, but it is not clear that two PRAs are necessary. One good one would be enough. For reasons of credibility and comparability with commercial PRAs, it is very desirable that the PRA be done under the guidance of a commercial practitioner. The PRA should be, and I believe is planned to be, a level 3 PRA, that is, it should evaluate public consequences and their probability as well as the probability of a core-damaging accident and confiner loss of integrity.

The value of a PRA lies not only in the fact that it provides an estimate of accident probability and consequences, but also in that it forces the analyst to inquire into the types and probabilities of possible accidents in a systematic, disciplined way. In order to gain the full benefit of a PRA, there must be active involvement in it by the engineers and others who will have a continuing association with the plant and who, in the future, can, with the aid of the PRA, evaluate changes or occurrences which may not have been considered when the PRA was done originally. To turn the doing of a PRA over to a PRA practitioner to be done largely with his own people is to deprive the sponsor of much of the benefit of doing the PRA. The role of the practitioner should be that of supplying specialized codes, advice, and assistance.

In performing the PRA, particular care should be taken to include consideration of accident scenarios like those now considered in NRC severe accident analyses. High-consequence low-probability scenarios such as complete plant black-out (including loss of ECCS diesel-driven pumps) and the introduction of water into the reactor onto hot fuel following an extended loss of coolant have not been considered in the N-Reactor so far. The result is that the consequences of really severe accidents are not included in the NUSAR. Although such accidents should come to light as part of the PRA, there is no reason to defer examining those that can be identified now; they can and should be separately analyzed at once without awaiting the completion of the somewhat slow PRA process.

It is interesting, and it may be significant, that a search of the available Soviet literature discloses little attention on the part of the Soviets to PRA until quite recently.

I strongly recommend that a probabilistic risk assessment on the N-Reactor be completed expeditiously and as indicated above. Selected potential severe accident sequences should be analyzed at once, even though it would be expected that they would also emerge and be analyzed during the PRA.

5. Intensification of Process Tube Monitoring is Endorsed

The Design Review Team recommended intensification of the program of monitoring the condition of the Zircaloy-2 process tubes. I do not expect deterioration of the process tubes to be the life-limiting aspect of the N-Reactor or to become a safety problem. But the progressive embrittlement of the tubes due to fast neutron bombardment and hydrogen absorption will continue as long as the reactor is operated. Because the Zircaloy is tougher and less susceptible to brittle failure at high temperatures than at low temperatures, the most critical condition for tube failure is that of cold hydro-testing. Process tube failure during cold hydro-testing would be a relatively benign accident, since it would be expected to produce no fuel failures. Thus, cold hydro-testing, which is a required routine already, provides an excellent way of detecting excessively embrittled or weak tubes. The process tube monitoring program, in which tubes are removed from the reactor at stated intervals and destructively examined is another excellent way of following the changes in process tube properties, and I support the recommended intensification of that program.

6. Creation of an Alternate Control Room is Supported

It is a standard NRC requirement that it be possible to safely shut the reactor down from a location other than the main control room. There are plans to create an alternate control room in the southern end of Building 109 at the N-Reactor. This will provide assurance that if the main control room is uninhabitable or lost for other reasons, there will still be a chance of putting the reactor into a safe, stable state. Care should be taken that habitability of the alternate control room is not lost due to whatever may have caused the loss of the main control room. With this caution I endorse the plan for creation of an alternate control room.

7. INPO Reviews of N-Reactor Operations Should Be Instituted

The DOE review group which produced the "Technical Safety Appraisal of the N-Reactor," referred to earlier in this report, identified a relatively large number of recommended improvements in a wide variety of areas such as organization, administration, operations, maintenance, training and certification, emergency readiness, technical support, radiological protection, personnel protection, quality assurance, security/safety interface, and fire protection. Although one would expect that, even in a well run organization, an intensive review by a large group of auditors would reveal a fair number of discrepancies of these kinds, the number reported in this case significantly exceeds what would be expected in a commercial nuclear power plant. With few, if any, exceptions, the identified discrepancies are not matters of direct safety concern, but in the aggregate they appear to be significant.

Most of the deficiencies or discrepancies reported are of a type which can be corrected by suitable action on the part of the contractor's manager and his staff. My conclusion is that it would be well for DOE to adopt the commercial practice of periodic review by the Institute of Nuclear Power Operations (INPO). Situations similar to those reported to exist in the N-Reactor have not been uncommon in the commercial nuclear power industry. INPO was created, in part, to provide a within-the-industry means of identifying the best practices, particularly those which are the direct responsibility of management, and to communicate, on a relatively confidential basis, to each plant how its own practices could be improved if necessary. INPO inspections are recurrent and previous recommendations are closely followed up to ascertain what response they have produced.

I recommend that the N-Reactor contractor arrange with INPO for regular reviews similar to those carried out by INPO in commercial plants and that INPO's recommendations be regarded by the N-Reactor contractor and by DOE as having as much force for the N-Reactor as INPO's recommendations for commercial plants have for those plants.

8. A Standing Technical Oversight Group Should Be Created

N-Reactor technical personnel have repeatedly, and over a period of many years, voiced the concern that, because of the unique design and purpose of the reactor, they might become somewhat insulated from events, technology, and concerns arising in commercial reactors. This is a real possibility for which the N-Reactor technical people have partly compensated by making extensive use of the resources of the Pacific Northwest Laboratory and the Hanford Engineering Development Laboratory, and by setting up technical review groups made up of outside experts. What seems to be missing, however, is the kind of review which could come from a group like the Advisory Committee on Reactor Safeguards (ACRS), although I believe that it would be advisable that the group have more intimate contact with the N-Reactor than would be possible for the ACRS. In particular, its contact with the N-Reactor should be close enough that it would be able knowledgeably to take the initiative in deciding what subjects to review, rather than relying on the N-Reactor to designate those subjects for it.

I wish to make it clear that this recommendation is not a criticism of the technical competence or dedication of the N-Reactor technical staff. It is the kind of recommendation which I would make to any technical group, no matter how competent, which had a responsibility like that of the N-Reactor group.

I recommend the formation of a standing technical oversight group for the N-Reactor.

9. DOE and Contractor Safety Responsibilities Should Be Better Defined

The responsibility for the safety of the N-Reactor appears to be shared between the DOE and the contractor. During one of the July presentations by DOE representatives, the question of the partitioning of this responsibility between the two parties was raised. It was surprising that no crisp statement of their respective responsibilities was given. Granting that a question of this importance might need to be answered carefully, the impression remains that there may be some confusion on this point.

During the General Electric Company's period of stewardship of the N-Reactor, it was understood that the contractor was supposed to satisfy himself that the reactor and its operation were safe and met all applicable regulations. The contractor was under no obligation to operate the reactor, if in his judgment, it was unsafe to do so. It was the obligation of the government to provide the funds to build and maintain a reactor which, the contractor agreed, could be operated safely. The

The obvious corrective measure is the installation of an ion exchange system through which the presently discharged water would be passed and re-used as reactor coolant. This type of reactor coolant purification is used on a much larger scale by commercial nuclear power plants of both PWR and BWR types.

I recommend the installation of a water purification system for the recovery of waste reactor coolant.

11. An Alternate Plan for Handling Accident Waste Water is Needed

In the event of a severe accident at the N-Reactor, it is likely that a considerable volume of highly contaminated water would result from cooling failed fuel. I understand that the contingent plan, in such a case, is that this waste water would be discharged into a pit in the desert in the general vicinity of the reactor. Inevitably this would result in long-lasting contamination of the ground, with a strong likelihood that the river also would become contaminated. I judge that a better plan for handling this waste water must be developed even though there is no expectation of ever having to use it.

At Three Mile Island Unit 2, the contaminated coolant overflowed the quench tank and spilled into the basement of the reactor building where it stayed until, a few years later, it was processed through ion exchange equipment. It appears to me that a similar solution could be devised at N-Reactor, perhaps with some building modifications to assure containment of the waste water.

I recommend that studies be made at once, and followed up with suitable action, to devise an acceptable way of dealing with the waste water from a severe nuclear accident.

RESPONSE TO THE SECRETARY'S REQUESTS

In addition to requesting that I perform a safety review of the N-Reactor, you requested that I comment on the Chernobyl-4 accident as it might apply to the N-Reactor.

I have reviewed the written material relevant to the Chernobyl-4 type of reactor and to the Chernobyl-4 reactor itself. The literature is voluminous and informative, and serves to emphasize certain critically important differences between the Chernobyl-4 and N-Reactor. In particular, the positive void coefficient of reactivity at Chernobyl, the very complex systems for controlling reactor power and power distribution, and the essential absence of any meaningful containment are notable.

In the course of my review of the N-Reactor, I gave special attention to the question of how it is known that the N-Reactor void coefficient is negative and how the reactor power distribution is controlled. On both counts the N-Reactor is far safer and simpler than Chernobyl. I have commented above on the N-Reactor containment situation which, while of concern, is certainly to be preferred to that at Chernobyl-4, and is, in my opinion capable of adequate correction.

government, of course, had similar veto authority over anything which it considered unsafe. In matters of contractor-proposed safety betterment, which were aimed at removing risks that could be tolerated for a short time, and which were in funding competition with other betterments, the government and the contractor agreed on priorities.

I would hope that a similar arrangement still persists, but I have seen no statement to this effect.

On the DOE side, the responsibility for N-Reactor safety does not seem to be clearly assigned below the level of the Secretary himself. Specifically, it is not clear to me what official or officials within DOE have the authority to shutdown the N-Reactor for reasons of safety without recourse to higher authority. It is also not clear where DOE has assigned the responsibility for deciding what safety improvements to fund and on what priority.

I recommend that DOE make a clarifying statement regarding the safety responsibilities of the N-Reactor contractor and of DOE in its various organizational components.

10. Coolant Bleed-Off Discharge to the Ground Should Be Discontinued

Except for liquid pathway discharges, the N-Reactor has little impact on the environment. However, two types of liquid discharges are of concern. One is the normal bleed-off and leakage from the primary coolant loop of about 1100 gpm. The other is the contingent plan to similarly discharge, in a severe accident, the contents of the primary loop which may possibly contain a large quantity of fission products from failed fuel. The former concern will be discussed under this item; the latter under the next one.

In order to maintain the necessary purity of the water in the primary cooling loop, about 1100 gpm of it is bled off or leaks off and is discarded at a nearby percolation site. The discharged water, about 0.7% of the reactor throughput, is allowed to percolate into the soil, and eventually emerges as springs at the edge of the nearby Columbia river. Although fuel failures are infrequent, normally one or two per year, one does occur occasionally with some release of fission products to the reactor coolant. In addition, "tramp" uranium on the fuel or in the process tubes can fission and release fission products to the coolant. The retentive nature of the soil at the N-Reactor is such that, of the released fission products, only radioiodine has been appearing in the riverside springs in quantities which require taking credit for dilution by the river itself to bring the concentration below drinking water limits. Recently, radiostrontium has appeared in the springs. In response to this, a new percolation site, more distant from the river than the old one, is now in use.

At no time has discharge of reactor coolant to the ground been harmful to users of the river, and there is no indication that a harmful condition would arise in the next several years. But this represents an environmentally poor practice.

The principal management lesson to be learned from the Chernobyl accident is the necessity for having good procedures, good training in their use, and close supervision to see that they are used. This is part of my reason for strongly urging INPO reviews of the N-Reactor on a regular basis.

The principal technical lesson is that reactors with void coefficients, which are positive over any appreciable part of the operating range, are not suitable for power production without extensive automatic noncancellable safety features that the RBMK reactors do not have. Because of the important basic differences between the RBMK reactors and the N-Reactor, an accident of the Chernobyl type would be impossible in the N-Reactor.

The Deputy Secretary of the Department of Energy also made a request for comments on the reports of the three review teams that had been created by the Department to do reviews on the N-Reactor. Those reports are identified at the beginning of this report. I have reviewed all of them and believe they represent thorough reviews in their respective areas. Their conclusions and recommendations are well founded and I support all of them. The Deputy Secretary also asked for an appraisal of the N-Reactor and its operation. As earlier stated, I believe that the reactor is being operated safely. This does not preclude the identification of ways in which improvements could and should be made.

In closing, I wish to express my appreciation of the very efficient and insightful assistance provided during this study by Mrs. Marilyn S. Smith of the DOE Office of Energy Research, by Dr. John Ireland, and by Dr. Glen Graves, both of the Los Alamos National Laboratory. Their staff work was excellent and of much value.

Sincerely,

/s/

Miles C. Leverett
Consultant

Updated August 1986

EDUCATION AND EXPERIENCE RECORD

MILES C. LEVERETT

BORN:	December 18, 1910, Danville, Illinois
FAMILY STATUS:	Married, no children
GRADE AND HIGH SCHOOLS:	Kansas City, MO and Kansas City, KS
UNIVERSITIES:	Kansas State University: B.S. Chemical Engineering - 1931 University of Oklahoma: M.S.E. Petroleum Engineering - 1932 Massachusetts Institute of Technology: D.Sc. Chemical Engineering - 1938

EMPLOYMENT:

1932-33	Marathon Paper Mills Co., Menaska, WI, Chemist. Worked on waxed paper processes.
1933-35	Phillips Petroleum Co., Bartlesville, OK, Chemist. Developed chemical procedures for stimulating production of oil from wells. Developed chemicals for treating oil field emulsions.
1938-42	Humble Oil & Refining Co. (now Exxon), Houston, TX, Research Associate. Did pioneering work on processes by which oil, gas and water migrate in oil fields. Several patents and papers.

MCL/cb/3934ST86

1942-43 Manhattan Project, University of Chicago, Associate Director - Technology Division. Did heat transfer and fluid flow on first helium-cooled reactor design for Pu production. Hold design patents.

Did heat transfer, fluid flow and general preliminary design work on first water-cooled Pu production reactors, later built at Hanford, WA. Was lead engineer in this work.

Did exploratory experiments and calculations on novel types of reactors, including BWR type.

Several patents and reports.

1943-48 Clinton Laboratories (Later Oak Ridge National Labs), Oak Ridge, TN - Director, Technical Division.

Directed groups which:

Modified air-cooled graphite reactor to increase power by 250%.

Designed, built and operated radium encapsulation facility

Designed, developed and operated factory to produce multi-kilo curie quantities of Ba^{140} from fission products.

Designed, developed and built facility for treatment and storage of fission product wastes from Pu separation plant.

Designed and developed high power density reactor core, which later became the Materials Testing Reactor (Idaho Falls) and is the prototype of all existing high power density test reactors.

Did earliest experiments on measurements of atmospheric dispersion of radioxenon, radioiodine, etc.

Made first presentation for a new reactor to group which later was designed at ACRS. Set pattern for reactor safety reviews.

1943-48 (continued)

Designed optical equipment for close inspection of hot fuel elements.

Supervised early work by architectural firms who later designed the permanent ORNL buildings.

1948-49 Humble Oil & Refining Co., Houston, TX - Senior Research Associate.

Continued pre-war work. Additional papers and inventions. Developed basic technique for estimating oil and gas content of oil sands. Technique and principles are still in use.

1949-51 Fairchild Engine and Airplane Co., "Nuclear Energy for Propulsion of Aircraft" (NEPA) Project, Oak Ridge, TN - Technical Director.

Managed 200-man team of chemists, metallurgists, ceramists, stress and structural engineers, aerodynamicists, aeronautical engineers, physicists, instrumentation and electronic engineers, biologists and health physicists.

Developed the two most promising concepts for nuclear-powered flight.

Had extensive interaction with AEC, USAF, USN, aircraft manufacturers and aircraft engine companies.

1951-61 General Electric Co., Aircraft Nuclear Propulsion Department, Evendale, OH - Manager - Engineering.

Managed 800-man team of chemists, ceramists, metallurgists, physicists, stress and structure engineers, aircraft engine specialists, control and instrumentation specialists, health physicists, test engineers and computer specialists.

Built an outstanding laboratory and development facility and organization. Pioneered extensively in high temperature materials, originating much technology later used in the Space Program and elsewhere.

1951-61 (continued)	
	Built first and only aircraft-type engines to be powered by nuclear reactors, later tested successfully at Idaho Test Station.
	Became charter member (1956) of GE Reactor Safeguards Committee which reviewed all work done by GE Atomic Power Equipment Department on commercial nuclear reactors. Continued as a member of this group until 1964 when it was broadened to cover all potentially hazardous activities of GE. Became chairman at that time, continuing until 1967 when the Committee was discontinued. Then took on full-time safety/quality/reliability duties at San Jose.
	Aircraft project was discontinued by government in 1961.
1961-62	General Electric Co., Hanford Laboratories, Richland, WA - Consulting Engineer.
	Made numerous special studies for management on methods of improving plant operation, safety, possible new products.
	Plants studies included production reactors, fuel manufacturing plants, fuel reprocessing plants, test reactors, plutonium recycle reactors.
1962-67	General Electric Co., Hanford Atomic Products Department, Richland, WA - Manager - Research & Engineering.
	Had charge of technical and safety aspects of the construction completion, pre-op testing, startup and operation of the N-reactor, a combination Pu producer and power producer. (N-reactor led the world in electrical energy generation for many years).
	Solved numerous problems in corrosion, mechanical, fuel, vibration, control, power distribution, by-product production, steam generation, safety and electronic breeds typical of a new power reactor.
	Developed methods for producing tritium and other valuable radioisotopes as by-products.

1967-75 General Electric Co., San Jose, CA - Manager - Safety & Quality, later Manager - Nuclear Safety Assurance.

Responsible for overseeing all nuclear safety activities in Nuclear Energy Division, and advising Division General Management.

Reviewed all new product design features.

Reviewed procedures, organizations, methods of all NED departments where safety could be a consideration.

Followed each project from inception to turnover; reviewed any special safety, reliability problems.

Conducted Operational Readiness Review on each plant several months before fuel loading. Consisted of leading a team of experienced engineers in a study of the project and its history, and a comprehensive review of the actual plant, looking for anything which might interfere with safe and reliable startup and operation.

Participated in corporate office studies of fuel reprocessing, nuclear reactor business, etc.

Consultant to Oak Ridge National Laboratory on its Nuclear Safety Program.

Consultant to Lovelace Foundation (Albuquerque) on its Fission Product Inhalation Program.

Consultant to United Nuclear Industries (Richland, WA) on N-Reactor.

Set up and managed Division Quality Assurance organization.

Member since 1969 of Niagara Mohawk Safety Review and Audit Board, with cognizance over Nine Mile Point Unit 1, Nine Mile Point Unit 2 (future), and J.A. FitzPatrick Nuclear Power Plant, operated by Niagara Mohawk.

1976-86 Private consultant on nuclear power reactor safety. Consulted for General Electric and various utility and other reactor owners or operators.

At Electric Power Research Institute:

Oversaw first comprehensive industry report on Three Mile Island accident.

Chaired Industry Degraded Core (IDCOR) Technical Advisory Group.

Consulted on Source Term Program.

Participated in setting up Institute of Nuclear Power Operations (INPO)

PROFESSIONAL ACTIVITIES AND HONORS:

Sigma Xi, member Society for Risk Analyses, member
American Chemical Society (former member)
American Institute of Mining and Metallurgical Engineers (former member)
American Physical Society (former member)
American Institute of Chemical Engineers (members)
  Received Robert E. Wilson Award, 1976
National Academy of Engineering, member
Former member Visiting Committee, Pennsylvania State University, Nuclear Engineering Department
Former member Visiting Committee, Massachusetts Institute of Technology, Nuclear Engineering Department
Former Chairman, American National Standards Institute Nuclear Standards Committee

ADDRESS

15233 Via Pinto
Monte Sereno, CA 95030
Home Tel. (408) 395-8432
Day Tel. (415) 855-2936

MCL/cb/3934ST86

N-REACTOR AND TYPICAL RBMK-1000 COMPARISONS

A. Overall Design Characteristics	N-Reactor	RBMK-1000
Reactor type	Horizontal pressure tube-pressurized water-graphite moderated	Vertical pressure tube-boiling water-graphite moderated
Design power generation (MWt)	4080	3140
Electrical power generation (MWe)	860	1000
Inlet temperature (avg. °F)	400	518
Outlet temperature (avg. °F)	543	543
Average steam quality at core exit (%)	0.0	14.5
Operating pressure (outlet psia)	1600	1037
Total reactor coolant flowrate (lb/h)	83.2 x 10^6	82.5 x 10^6
Total number of pressure tubes	1003	1693
Lattice spacing	9 in. vertical x 8 in. horizontal	9.8 in. x 9.8 in.

B. Fuel Design		
Design	Tube-in-Tube Annular	Two 3.5 m 18 rod elements in series
Fuel material	U-metal	UO_2
Amount (MT)	365	192
Length (ft.)	34.8	22.96
Orientation	Horizontal	Vertical
Enrichment (%U^{235})	0.7-1.25	1.8-2.0
Average burnup (MWD/MTU)	1000-	20,000
Maximum channel power (MW_t)	5.0	3.0
Cladding	Zr-2	Zr/Nb
Pressure tube OD (in.)	3.26	3.46
Pressure tube wall thickness (in.)	0.275	0.157
Pressure tube material	Zr-2	Zr/Nb

C. Moderator Design		
Material	TSX graphite	Graphite
Operating temperature (°F)	932	1292
Amount (MT)	1800	2000

BIBLIOGRAPHY

1. V. G. Aden, et al., "Fuel Elements of the RBMK-1000 Reactor," Atomnaya Energiya 43 (4), 235-239 (1977) (translation).

2. A. P. Aleksandrov, et al., "Physical and Power Startup of the First Unit of the V. I. Lenin Nuclear Power Station, Leningrad," Atomnaya Energiya 37 (2), 99-107 (1974) (translation).

3. A. P. Aleksandrov and N. A. Dollezhal', "Development of Uranium-Graphite Channel Reactors in the USSR," Atomnaya Energiya 43 (5), 337-343 (1977) (translation).

4. E. P. Anan'ev and G. N. Kruzhilin, "Radioactive Safety Barriers in Nuclear Power Stations," Atomnaya Energiya 37 (1), 22-27 (1974) (translation).

5. R. W. Andrae, et al., "A Review of Four Safety Aspects of the Savannah River Production Reactor," Los Alamos National Laboratory letter report (Q-6) (August 1984).

6. M. Berman, "Hydrogen Behavior and Nuclear Reactor Safety," in Recent Developments in Hydrogen Technology, Vol. II (CRC Press, Inc., Boca Raton, Florida), Chap. 2, pp. 35-67.

7. M. Berman, "A Critical Review of Recent Large-Scale Experiments on Hydrogen-Air Detonations" (to be published in Nuclear Science and Engineering).

8. H. W. Bertini, "Descriptions of Selected Accidents that have Occurred at Nuclear Reactor Facilities," Nuclear Safety Information Center, ORNL/NSIC-176 (April 1980).

9. V. I. Budnikov, et al., "Stability of the Radial and Azimuthal Energy Distribution in a Boiling-Water Reactor," Atomnaya Energiya 45 (5), 331-335 (1978) (translation).

10. A. L. Camp, et al., "Light Water Reactor Hydrogen Manual," NUREG/CR-2726, SAND82-1137, Sandia National Laboratories and General Physics Corporation (1983).

11. A. L. Camp, et al., "HECTR Version 1.0 User's Manual," NUREG/CR-3913, SAND84-1522, Sandia National Laboratories (1985).

12. Yu. M. Cherkashov, et al., "Mathematical and Experimental Study of Emergency Cooling of RBMK-1500 Reactor in Case of Maximum Credible Accident," Russian 4, 23-33 (1981) (translation).

13. V. M. Chernyshenko, "Construction Parameters for Chernobylskaya AES Given," Russian 11, 2-6 (1984) (translation).

Special Appointment
August 1, 1986
DOE-Forrestal Building
Washington, DC

SUBJECT: Request for Additional Information

Consultants Present: Roddis, Tape, Wilkinson

DOE Representatives Present:

J. Salgado, Under Secretary, DOE

M. Walker, Assistant Secretary for ES&H, DOE

A. Trivelpiece, Assistant Secretary for Energy Research, DOE

J. Gilbert, Executive Assistant to the Assistant Secretary for Defense Programs, DOE

E. Hanrahan, Special Assistant to the Under Secretary (DOE)

1st Joint Briefing
May 22-23, 1986
DOE--Forrestal Building
Washington, DC

Consultants Present: Roddis, Tape, Pigford, Lewis, Leverett

Speaker	Title & Organization	Subject
E. Hanrahan	Special Assistant to the Under Secretary (DOE)	EPA Task Force on Chernobyl
D. Bunch	Deputy Assistant Secretary for Nuclear Energy, DOE	Chernobyl Accident
M. Walker	Assistant Secretary for ES&H, DOE	DOE Reviews of N-Reactor
G. Oertel, N. Klug	Deputy Assistant Secretary for Safety, Health & Q.A., DOE Team Leader for N-Reactor Special Safety Review, DOE	Quick Response Safety Review of N-Reactor in Light of Chernobyl
C. Simpson, J. Ford	Director of Office of Nuclear Materials Production, DOE Office of Nuclear Materials Production, DOE	N-Reactor Safety Programs
J. Salgado, S. Foley, M. Walker, A. Trivelpiece, E. Hanrahan	Under Secretary, DOE Assistant Secretary for Defense Programs, DOE Assistant Secretary for ES&H, DOE Assistant Secretary for Energy Research, DOE Special Assistant to the Under Secretary, DOE	Briefing to Consultants on DOE Issues Concerning Chernobyl and N-Reactor

Santa Barbara, California

October 1, 1986

The Honorable John S. Herrington, Secretary
United States Department of Energy
Washington, D.C. 20585

Dear Mr. Secretary:

After the Chernobyl accident in late April of 1986, you asked a half dozen of us to provide you our views on the safety of the N reactor at Hanford, in view of the Soviet event. The N reactor is a light-water-cooled graphite-moderated pressure-tube reactor without a traditional containment, properties it shares with the RBMK-1000 at Chernobyl, but it is otherwise quite different. The reactor has also been operating for nearly twenty-five years, so that, in fact, safety reviews were already under way in the Department, prior to Chernobyl. The response to Chernobyl was to accelerate the internal reviews, to appoint our external group, and, subsequently, to ask the National Academy of Sciences to look at all the production reactors over a longer period. We were promised complete access and cooperation from the Department. This is my report to you on this matter.

Let me say at the outset that your specific wish [your letter of May 2 to Dr. Roddis] to be "absolutely certain ... that there is no possibility of an accident similar to the one that occurred in the Soviet Union" cannot be fulfilled, simply because risk is a matter of degree, and the complete avoidance of risk is a fantasy. I will stress this point throughout, because it seems to be imperfectly understood within the Department. We often heard people opine that the reactor was "safe", and that is a meaningless observation. Decision making involves either overt or subliminal balancing of risks and other costs against benefits. Just as there are (allegedly) no free lunches, there are no risk-free technologies. The risk is real, and no risk is worth accepting without commensurate benefit, while great risks are acceptable in return for great benefits. The benefits associated with operation of the N reactor lie in its provision of special nuclear materials for defense programs, and the assessment of the value of these benefits lies without our charter. Thus, though I can advise you of the implications of Chernobyl for the reactor, and can even say what can be done to reduce the risk, I can only provide a personal view of the implications for continued operation of the reactor. I will do so at the end.

There are many reasons why the N reactor deserved attention long before Chernobyl. It is an old reactor, designed in the '50s, and does indeed lack traditional containment. At over 4000 MW$_t$ it has the highest power level in the United States. It is a unique design, so that the benefits of operational experience in other reactors are of only limited value in the maintenance of its safety. It is often said that it meets all safety criteria for commercial reactors, but that is not particularly meaningful, since only those criteria of broad applicability are relevant to this type of reactor, and there are none that are uniquely relevant. In addition, compliance with regulations is a chancy thing, as those in the commercial field have learned, and one can only learn whether one is in compliance (just as in the law) when the final ruling has been handed down by the final arbiter. This has not been done. Finally, the argument that a reactor that has operated safely for so long must be safe is statistically specious, since the actual operational experience is negligible compared to the level of safety that is required. The Department is to be commended for having started the internal review process before the stimulus of Chernobyl.

The specific details of the accident at Chernobyl are, for the most part, only marginally relevant to the N reactor. The N reactor (I am assured, but have not personally checked the calculations) has a negative void coefficient of reactivity, so the direct cause of the reactivity transient that occurred there is missing here. The graphite fire was a result of the accident, and the main damage was already done when the graphite caught fire, so the graphite moderator is a misleading similarity. Chernobyl has simply provided a reason to take a closer look.

Yet there are similarities which *are* relevant. Of these, only one is hardware — the lack of conventional containment -- and the remainder are institutional. I will devote much of this report to the latter, so let me begin with containment.

Nuclear safety, as practiced in most parts of the world, is predicated on a philosophy called "defense in depth", which means that there is a sequence of serial barriers to the release of radioactivity to the environment, and that the breach of one barrier leads only to another. A sturdy containment is normally used as the last such barrier, so that disaster within the containment is not likely to lead to release of substantial amounts of radioactivity. There are different ways in which one can allocate safety resources, and there is no *essential* role for containment. It is possible to envisage equally safe reactor designs in which containment plays a greater or lesser role, or even no role at all. Nonetheless, standard practice nowadays is to provide containment as a barrier of last resort.

That was not entirely foreseeable in the late 1950s, when the N reactor was designed. Yet, in 1958, the Advisory Committee on Reactor Safeguards (ACRS, then attached to AEC, now to NRC) wrote a letter about the N reactor, stating that it was "essential" that the reactor be contained. Since the ACRS was an independent advisory body of experts, though functioning within AEC, this was a significant recommendation. In 1960 the ACRS accepted the uncontained design, for reasons which would surely not pass muster today (" containment of this one reactor will not greatly change the overall safety picture at Hanford" and "its use will not significantly increase the present hazards of the Hanford operations"). The other reactors referred to are now all shut down, and I do not know of any comparable external reviews since. From 1960 through 1967, when the letters ceased, the ACRS continued to state that it was its view that the hazards of the N reactor exceeded those of licensed reactors, and that its continued operation "can only be justified by production requirements". Though I am currently a member of ACRS (and therefore have an apparent conflict here, whose effect you must judge) I can not pretend to predict what might happen if the matter were to come up today. What I do know is that all reactors licensed since then, in this country and most others, have been conventionally contained.

My personal view is that I would be disinclined to license a commercial uncontained reactor, barring an extraordinarily convincing demonstration of the low probability of an accident, but that does not lead me to recommend containment for the N reactor. The objective of a safety program, including design, construction, maintenance, and operation, is to protect the health and safety of the public against a major release of radiation. As mentioned earlier, this can be achieved in sequential steps, by reducing the probability of an internal release, and, if such a release occurs, reducing the probability of its escape to the biosphere. There is no magic in the allocation of safety assurance between these two barriers, and one can conceive of equally safe reactors that meet their objectives in different ways. In the commercial field, most of the emphasis has been on preventing severe core damage (aka core melt), with the containment as the final layer of protection. The N reactor has a different emphasis on the various elements of safety, which can in principle be just as good, but which has not been demonstrated to be so. Indeed, the fundamental premise of the N reactor confinement system is that the release of high pressure steam and the release of radioactivity will be sufficiently separated in time to allow valves to close behind the steam and block the subsequent radioactivity release. That was not the case at Chernobyl, but the relevance to the N reactor accident sequences is not clear. This is precisely the sort of question that ought to be answered by a level three probabilistic risk assessment (PRA), as discussed below.

A final point on containment follows logically. If the decision were made to invest the very large sums required to enhance the safety of the reactor, it is not clear that the resources are best spent on containment. It is very likely that analysis would demonstrate that one can buy more safety enhancements in other ways, at lower cost.

Now to other matters. Ours is a diverse group, representing a variety of skills and experience, so it should be no surprise that we have different perspectives. For that reason, I believe that it is healthy that we are filing separate reports -- each can be mined for its separate ore. My own predilections should be obvious from what follows -- I tend to see technical issues in the context of the institutional forms that nurtured them. Therefore, though each of the technical problems can be solved individually (and they are real and must be dealt with if the reactor is to be continued in operation), still more needs to be done if we are to provide reasonable assurance for the future. My fellow consultants will, I am sure, provide a number of well considered recommendations for specific technical fixes. I endorse nearly all of these, but most specifically those for the expeditious provision of remote shutdown capability and for a more survivable ECCS.

After the accident at Three Mile Island in 1979, and after the Challenger accident earlier this year, the President appointed an *ad hoc* committee, external to the Agency involved, to study the accident and to make the necessary recommendations. (It is interesting that the Soviets did the same thing after Chernobyl.) In each of these two cases, the Kemeny and Rogers Commissions, the group found and sharply criticized widespread complacency generated by a long period of accident-free operation. That was, in my view, the central problem at Chernobyl. I have found the same problem here. It is by no means universal, nor is it as pronounced as it apparently was at Chernobyl, but is sufficiently common to be cause for serious concern. Apart from its direct effect on the safety of the reactor, it can also affect the diligence with which one studies the problems. Wigner once said that there are three ways to approach a problem: to seek a solution, to prove that the problem is insoluble, or to prove that there is no problem. There is too much of the latter in the NUSAR, and it persists to a disturbing extent in some of the current internal reviews. Jefferson said that eternal vigilance is the price of liberty; that is also true of safety.

I regret to say that there was also evidence of complacency at the plant, at the lower levels. Admittedly, I have had only a short visit, so some of the observations may have simply been aberrations from the norm, but there were an uncomfortable number of small but significant deviations from familiar safety practice. The sense that came through was one of people doing a job in a context of safety rules whose significance had somehow been lost, and which were therefore not deemed very important. This was somewhat puzzling, since the upper management seemed well focused; yet the plant workers must somehow reflect the values passed on from above.

This is not as defamatory as it may sound. It is virtually impossible to maintain the necessary sense of insecurity and concern for the occurrence of improbable events, when everyday experience seems to belie the need. It requires constant attention to maintain a taut ship. Pilots have a similar problem, as do the Air Force personnel who man the missile silos, to say nothing of the vast majority of drivers. And it is still a problem in the nuclear industry, despite the Kemeny Commission report. Few humans will perform to the best of their ability, year after year, with only inspirational speeches to motivate them. I will have some suggestions below.

During recent decades there have been many serious incidents in commercial reactors, ranging from scram failures to fires, to control system failures, to human errors of commission and omission, etc. Most have been benign (all except Chernobyl, in terms of exposure of the public to radiation), and they have contributed to a base of operating experience which, if properly exploited (and therein lies another tale), can contribute mightily to our understanding of the vulnerabilities of those reactors. Because it is unique, the N reactor can benefit only in part from that operating experience, and I found little in the way of systematic effort to derive even those benefits. (The isolation of the N reactor community is a subject to which I will return.) Therefore, there is no way to understand the reactor-unique accident modes (such as an in-core pressure tube rupture), other than through theoretical analysis. I have no reason to believe that the analyses are not done well, but there is simply less assurance than there is in the commercial world that everything important has been considered. Even in that world, most serious incidents are surprises.

It is therefore commendable that the Department is sponsoring a PRA for the reactor, because that is a systematic way to uncover accident sequences that have not yet occurred, as well as to explore their potential consequences in some detail. It is my understanding that the current plan is to expand the originally intended scope of the PRA to level three, and I would strongly urge that that be done. While that should enhance our understanding of the possible events in the reactor, it is important that we not put too much faith in the detailed results of the study. Leaving apart the inevitable uncertainties in any statistical analysis of this sort (uncertainties which are revealed by the analysis, not, as some seem to think, created by it), the reasonably high quality of PRAs in the commercial field has been achieved by a small community of practitioners over years of experience with a particular class of reactors. In fact, one of the principal criticisms of PRAs, that they are necessarily incomplete, is best met by comparing them with operating experience. In the case of the N reactor this assurance is not available, so that the PRA has to be more properly compared with the first that was done on commercial plants, not with the current state of the art. Still, the PRA is the best way to go, and its value is at least as much in the fact that the performance of a PRA forces disciplined thinking about the vulnerabilities of the plant, as it is in the final results. It is important, for quality control, that the PRA also be subjected to peer review, outside the DoE family.

I have been unable to understand the management structure, top to bottom, that envelops the N reactor, and believe the line of responsibility to be too long and too tenuous. It resembles a family operation. Given the importance of direct management involvement to the safety of any reactor, as has been so often demonstrated in the commercial domain, this is not a small matter. It is not entirely clear to me where direct responsibility lies at DoE headquarters in Washington, since responsibilities for the product and for the safety are divided. In turn, it has to be said that the local Operations office, though manned by competent and conscientious people, appears to be only loosely coupled to Headquarters. Finally, at the end of the chain, there is the contractor. This is a balkanized arrangement which cannot but detract from safety, despite the best intentions and dedication (which I do not question) of all involved. Just the simple fact that Headquarters safety responsibility does not include shut-down authority is symbolic of Department priorities. Finally, there is no external peer pressure encouraging excellence of the entire structure.

Before 1975, when the AEC was split into NRC and ERDA (in my view an error similar to that which led to the breakup of the telephone company), commercial licensing and defense programs were housed under one roof, so that the standards tended toward uniformity, or at least comparability, for the two worlds. That ended and, rightly or wrongly, the commercial standards have become progressively tighter. I do not believe that the DoE has been able to keep up, largely because of its isolation.

I believe that the closed nature of the DoE community, and its loose coupling to the increasingly experienced commercial world, are central and fundamental problems, since we all need the incentive provided by peer judgment, to perform at our best. Even the interaction among your expert consultants has been beneficial. There are two options available to the Secretary which bear mention.

At the time of bifurcation of the AEC, the ACRS went with the NRC side of the house (along with the five Commissioners), leaving ERDA, and later DoE, without the review service ACRS had provided. Perhaps for this reason the Act specifically states that the Secretary of Energy may solicit help from ACRS directly, and this provides a potential avenue which few seem to have noticed. (I don't know of any case in which it has been done, though the law is clear.) I believe it would be constructive for the Secretary to ask ACRS to participate somehow in the medium term evaluation of the N reactor, whether through direct review or review of the PRA, or in some other way. This is a group of deeply involved supposed experts, not in the DoE family, who can be drawn on without involving the full paraphernalia of NRC itself. (I must reemphasize my apparent conflict in writing this paragraph. I don't believe I have a real conflict, but we live in a suspicious world.)

Another outside group that has been very beneficial in the commercial field is the Institute for Nuclear Power Operations (INPO), which was created after Three Mile Island to encourage and support operational improvements in commercial nuclear power plants. It is well respected and effective. I believe it would be worth while to ask INPO to conduct an operational review of the N reactor — a job that could be done in a few weeks, I am told. Though I may be wrong, I believe that it is only a matter of asking, and the results could be extremely helpful to you. The internal reviews have resulted in almost a hundred recommendations for improvement, many operational. It would be useful to hear from INPO.

Finally, let me turn to the bottom line question of continued operation of the reactor, bearing in mind the early comments about risks and benefits. We are talking about perhaps the next three to five years, the period before graphite growth makes major rebuilding or decommissioning inevitable. Long before then a decision must be made either to commit to a new production reactor, to rebuild the N reactor, or to accept a reduction in the U.S. production capacity. Such matters go beyond the boundaries of our charter.

In the last analysis, we are dealing here with a very large reactor, without conventional containment but with a novel and unique (but unproved) confinement system, and with a number of possibly significant shortcomings, such as lack of remote shutdown capability, lack of hydrogen mitigation facility, a somewhat less robust ECCS than one would like, a complex management structure, etc. For such a situation one would like an especially solid demonstration that the likelihood of an accident sequence that challenges the late lines of defense of the reactor is unusually low, and such a demonstration has not been made.

It is sometimes argued within the Department that twenty-three years of operation without a major accident are ample evidence of what you yourself have called "an outstanding safety record". At the risk of being pedagogical (for a professor, it is compulsive), it is worth exploring the statistical significance of the record. (Recall, though the analogy is somewhat misleading, that a record of twenty-four successful shuttle missions was used by some elements of NASA early this year to justify the twenty-fifth.)

It is extremely difficult to calculate the probability of a major reactor accident, and even more difficult, for other reasons, to decide what probability is acceptable. In the commercial arena, the NRC has, after years of debate and indecision, just recently promulgated a safety goal, which includes a probability objective for core melt of less than one in ten thousand per reactor year. The goal for the probability of a major release of radioactivity is much lower, but the NRC is dealing with conventionally contained reactors, so that is less relevant. If your intent is to hold the N reactor to a comparable safety objective, then twenty-three years of operation are simply irrelevant. The probability of a major accident can simply not be inferred from such short operating experience. Three Mile Island happened after several hundred reactor-years of U.S. commercial experience, and Chernobyl after thousands of reactor-years of world-wide experience. On a *statistical basis* alone, a twenty-three year period of accident-free operation falls far short of providing the necessary assurance. Such assurance can only come from a competently performed PRA, and even then it will be beset with large uncertainties.

We were sometimes asked whether it is "safe" to operate the reactor for the next few years, and I have emphasized that that is an empty question. Those who ask it often have in mind a kind of dichotomy, in which it may be "unsafe" to operate it for (say) six years, but "safe" to operate it for three. In fact, whatever the probability per year of a major accident may be (and we don't know quantitatively), it is reasonably cumulative from year to year. Twice as many years entail roughly twice as much risk. There is no magic period which is devoid of risk. Therefore, any decision about the continued operation of the reactor must be made by balancing that (currently unknown) cumulative risk (and other costs) against the value of the product. One might argue that one can accept a higher level of risk in a single production reactor than one can in each of a hundred commercial reactors, but such an argument should be made openly, if at all.

An additional psychological point bears mention. During the Rogers Commission hearings on the Challenger accident, one of the major participants in the fateful discussions of O-ring reliability the night before the launch testified that "we were being put in a position to prove that we should not launch rather than ... prove that we had enough data to launch". It is important to avoid that frame of mind here too.

In the end, for all the reasons mentioned, I would recommend scheduling the permanent shutdown of the N reactor for the very near future, and concomitantly forcing a decision on a new production reactor. The requirements for special nuclear materials are, of course, largely controlled by matters outside the Department (for example, arms control negotiations or planned new weapons systems, to cite two opposite influences), but prudence would appear to dictate the need for an early decision. As you know, this has been an issue for years.

If you should decide otherwise, it is essential that the improvements recommended by my fellow consultants be implemented, with full awareness of the fact that too many changes at once can be antithetical to safety. The internal review teams must therefore provide priority lists for their own recommended changes. (Such lists may exist, but I have not seen them.)

Whatever your decision about the N reactor, I believe it important that the institutional issues that have been raised be addressed. The current structure is diffuse, encourages a defocusing of both safety responsibility and authority, and provides few weapons against complacency. These matters affect not only this reactor, but all the DoE facilities.

It has been a pleasure working with this distinguished and conscientious group, and with the capable and supportive staff provided by the Department. In particular, Marilyn Smith of DoE and John Ireland and Glen Graves of Los Alamos have been tireless and invaluable.

If any of the ideas presented in this short report need to be further developed, I would be happy (and obliged) to be of service.

Respectfully yours,

H. W. Lewis

October 1, 1986

The Honorable John L. Herrington, Secretary
US Department of Energy
1000 Independence Avenue, S.W.
Washington, DC 20585

Dear Mr. Secretary:

I was contacted by Dr. Alvin Trivelpiece, your Director of the Office of Energy Research, to become one of six independent members of an Ad Hoc consultant group to examine the technical and safety aspects of the Hanford N-Reactor in light of the Chernobyl accident.

Enclosed is my report concerning this subject.

Respectfully,

E P Wilkinson

E. P. Wilkinson

N-REACTOR SAFETY IN LIGHT OF THE CHERNOBYL ACCIDENT

E. P. Wilkinson

I was contacted by Dr. Alvin Trivelpiece, your Director of the Office of Energy Research, to become one of six independent members of an Ad Hoc consultant group to examine the technical and safety aspects of the Hanford N-Reactor in light of the Chernobyl reactor accident.

Our group was initially charged to:

- Review the facts and findings surrounding the Chernobyl accident.
- Based on those facts and findings, examine N-Reactor operations and safety procedures to ensure that all key technical questions and potential safety issues raised by the Soviet accident have been considered.
- Examine the information and findings from the Department's own safety reviews of N-Reactor to ensure that the relevant facts and findings from the Chernobyl accident have been addressed by the DOE teams.

Additional charges were added by Under Secretary Salgado in an early meeting with the independent consultants:

- Are all important issues being adequately addressed?
- Is the N-Reactor being operated safely?
- If not, can the N-Reactor be operated safely?

In carrying out my part of that tasking, I have had the benefit of:

- Charge letter to consultants,
- Voluminous material as shown in an extensive bibliography of documents,
- Several joint and special briefings as shown in schedule of agendas with supporting back-up material,
- A table showing comparisons of the N-Reactor and the Soviet RBMK-1000-type reactor,
- Back correspondence from the ACRS concerning the N-Reactor,
- N-Reactor Safety Assessment by Intex (Dietrich Report June 1983),
- Report of quick review by the DOE special safety team that examined graphite fire and confinement issues,

- Technical safety appraisal of the N-Reactor (July 1986),
- GAO report on nuclear safety comparison of DOE's Hanford N-Reactor with the Chernobyl reactor (August 1986),
- USSR State Committee report on the accident at the Chernobyl nuclear power plant and its consequences (August 1986),
- Design review of the N-Reactor (September 1986),
- DOE draft action plan to address recommendations from the N-Reactor special safety review, technical safety review, and design review,
- Cumulative analysis of ESH's N-Reactor reviews,
- Visits to DOE Headquarters, the N-Reactor at Hanford, and the Los Alamos National Laboratory, and
- Interaction and discussion with the five other members of the Ad Hoc consultant group, namely Dr. Miles C. Leverett, Professor Harold W. Lewis, Professor Thomas H. Pigford, Mr. Louis H. Roddis, Jr., and Dr. Gerald F. Tape.

The consultants carried out their investigations concurrently with the various DOE review groups. From review of that extensive amount of information and from my own experience, I have drawn conclusions and recommendations which are my own and which are expressed in summary form later in this report.

I wish to recognize the support of the DOE staff, both at Richland and Headquarters, of the contractor, UNC, and of staff at the Los Alamos National Laboratory. I especially appreciate the very efficient and thoughtful assistance of Mrs. Marilyn S. Smith of the DOE Office of Energy Research, and of Dr. John R. Ireland and Dr. Glen Graves, both of Los Alamos National Laboratory.

The requested review of the facts and findings surrounding the Soviet reactor accident at Chernobyl, N-Reactor operations and safety procedures, key technical questions and potential safety issues raised by the Soviet accident, the information and findings developed by the Department's safety reviews of the N-Reactor, and other information made available, and as tabulated previously, lead me to the personal conclusions and recommendations that follow.

Conclusions

1. There are no known deficiencies that mandate an immediate shutdown of the N-Reactor for safety reasons.

2. The various DOE safety reviews appear to have been competently done. In the aggregate, the number of discrepancies identified is significant and indicates that prompt corrective action is required.

3. Historically, the N-Reactor has not always been kept up to date on safety-related design changes or maintained in an excellent material condition.

4. The N-Reactor is not as safe as our US commercial plants. It should be recognized by the DOE that it does not meet all present-day standards for commercial reactors.

5. The N-Reactor can be operated safely. But, numerous improvements are needed operationally, administratively, in maintenance, in training, and in design modifications to enhance the level of operational safety and to support continuing operations for the next several years.

6. Compared to our commercial reactors there is a considerably greater man-rem exposure for N-Reactor personnel.

7. The N-Reactor has exceeded its nominal 20-year life. Items such as graphite growth, zircalloy-2 tube embrittlement, and long-term deterioration of components indicate the necessity of final shutdown, or complete renovation in the early 1990s.

8. There are major safety-related design differences between the N-Reactor and the Chernobyl reactor. The N-Reactor, for example, has a negative void coefficient, much less complex controls, two independent fast-acting scram systems, and is shutdown for refueling. The series of operating errors, conduct of special tests not compatible with reactor control, disabled safety systems, and disregard of procedures that occurred at Chernobyl are almost unbelievable. It is considered that there are more rigid controls and adherence to procedures at the N-Reactor. It appears that in the event of a major accident at the N-Reactor there could be containment failure similar to that at Chernobyl. But, in that event, the impact on the surrounding area would be much less because of the lesser population density. In summary, an accident of the type that occurred at Chernobyl is not plausible at the N-Reactor.

9. There is an apparent sense of complacency at many levels from the DOE staff on down through contractor operations personnel that "it can't happen here" at the N-Reactor. The major lesson from TMI-2 and Chernobyl-4 is that accidents can happen and, if they do, they may not match postulated scenarios. The possiblity of a major accident at the N-Reactor with significant release of radioactivity cannot be ruled out. The DOE should evaluate the degree of risk versus the need for production of defense materials. In that evaluation, the risk that a major accident with significant release of radioactivity to the environment would pose to the future of nuclear energy use in the US should be considered.

10. The hydrogen issue has not been adequately considered or answered.

11. The discharge of primary coolant into the soil is a poor practice and poses an environmental threat.

Recommendations

1. DOE review the risk, including the risk to the future of nuclear energy use in the United States, and make a decision as to whether to continue the operation of the N-Reactor. If the decision is to continue, then there are some high-priority operational, administrative, maintenance, training, and design modifications to accomplish to enhance the level of safe operation. Make the commitment to provide the resources to accomplish them.

2. If the N-Reactor facility is required for long-term production of defense material, recognize that major renovation or replacement will be required in the early 1990s. A replacement design could meet commercial standards and provide such features as containment, mitigation, better maintenance, lower man-rem exposure, etc. DOE should conduct a review and make a decision on this issue in a timely manner.

3. An action plan is under preparation to address deficiencies identified and recommendations from the N-Reactor special safety review, technical safety review, and the design review. Expand that action plan to include consideration of all known deficiencies from other sources. Prioritize items to be accomplished. Incorporate them into a living schedule. Provide the resources to accomplish them. Set up an action tracking system to follow up to ensure that schedule commitments are met.

4. Expand the training programs to cover personnel involved in operation, maintenance, support, and supervision of the N-Reactor. Ensure that training conducted meets the job requirements. Set up training and qualification standards patterned after the INPO criteria for commercial reactors. Include review of simulator training. Arrange for INPO assistance followed by accreditation reviews by INPO.

5. The N-Reactor is a special participant in INPO. Arrange for an early INPO operational evaluation. Arrange for continuing periodic INPO evaluations with their follow-up benefits.

6. Arrange for an INPO emergency preparedness review.

7. Assign a special group to review all recommendations related to deficiencies to identify underlying root causes so that action can be taken not only to correct deficiencies, but also to minimize probability of occurrence. It is understood that this is being set up under Del Bunch.

8. The potential hydrogen generation at the N-Reactor is greater than that at Chernobyl and many times greater than in our commercial reactors. Hydrogen mitigation should be provided. Hydrogen generation and distribution should be evaluated under various scenarios. Hydrogen indication equipment and more extensive compartment inerting and/or igniters should be provided.

9. Expedite conduct of a level 3 PRA. Ensure that personnel who will have long-term involvement with the N-Reactor participate.

10. Primary coolant discharge to the surrounding soil should be stopped. An ion exchange system is needed to purify primary coolant. In the event of a severe accident, a method to contain the waste water until it can be decontaminated is needed.

11. Certain modifications to design requirements have been endorsed by many reviewers, such as, remote shutdown capability, control room habitability, and backup emergency core cooling. Assign priority attention to their accomplishment.

12. Improve the effectiveness of the quality control and quality assurance programs at the N-Reactor.

13. Ensure that there is an effective on-site and off-site review of off-normal events that occur at the N-Reactor to ensure that underlying root causes are identified so that corrective measures can be taken.

14. Expand surveillance and monitoring of the N-Reactor to refine the estimate of date of end of normal life. In addition to zircalloy-2 tube embrittlement and graphite growth, include selected valves, systems, and components.

15. Establish a permanent system of outside technical review.

GERALD F. TAPE
CONSULTANT
6717 TULIP HILL TERRACE
BETHESDA, MARYLAND 20816

(202) 462-1676
(301) 229-6264

October 1, 1986

The Honorable John S. Herrington, Secretary
U. S. Department of Energy
Washington, DC 20585

Dear Secretary Herrington:

In accordance with the request in your letter of May 2, 1986, I have carried out a review of N-Reactor safety in the light of the Chernobyl accident. My report is enclosed.

It is generally concluded that the initiating event leading to the accident at Chernobyl could not occur at N-Reactor. There are, however, lessons to be learned from the accident. In my view, a major beneficial consequence has been the stimulation of the U. S. to conduct extensive reviews of N-Reactor safety and more thoroughly to examine very low probability but high consequence potential accidents.

The Department's reviews have been extensive. No safety related matter so serious as to warrant shutdown of the N-Reactor has been discovered. I support this finding. My report contains a number of recommendations, many of them overlapping those included in the various Departmental reviews.

Implementation of recommendations requires setting priorities and providing funding by the Department. Development of a logical action plan must be preceded by a determination of the short- and long-term role of the N-Reactor. I urge you to make such a determination promptly.

I wish to express my appreciation to the many persons who, in the Department, both headquarters and field, and in the contractor organizations, have provided briefings and special materials. The joint briefings arranged for all of the consultants appointed by you have been most beneficial.

I appreciate the opportunity of assisting the Department of Energy in this important matter. I would be pleased to provide further information, if you desire.

Sincerely,

Gerald F. Tape

Gerald F. Tape

N-Reactor Safety In The Light Of The Chernobyl Accident

Gerald F. Tape

Secretary Herrington requested six consultants to assist him in the Department of Energy's review of the N-Reactor design and operation in the light of the Chernobyl accident. Specifically, the consultants were to probe for safety related matters that were revealed in the examination and understanding of the Chernobyl accident and that had not previously been factored into the contractor's management and operation or the Department's oversight of ensuring safe operation of the N-Reactor.

The initial charge was as follows:

- The consultants will review the facts and findings surrounding the Soviet reactor accident at Chernobyl.
- Based on these facts and findings, the consultants will examine the N-Reactor operations and safety procedures to ensure that all key technical and potential safety issues raised by the Soviet accident have been considered.
- The consultants will also examine information and findings developed in the Department's safety reviews of the N-Reactor to ensure that the relevant facts and findings from the Soviet accident have been addressed by the review teams.

In an early meeting of the consultants with Under Secretary Salgado, he amplified the charges by asking several questions:

- Are all important issues being adequately addressed?
- Is the N-Reactor being operated safely? If not, can the N-Reactor be operated safely?

The Process

The consultants participated jointly in many meetings to receive briefings, to identify unanswered questions requiring further study, and to visit the N-reactor plant and talk to the contractor. The details of these common activities are to be found in the Appendix to this report. The support of the DOE staff, both at headquarters and Richland, and of the contractor, UNC, is gratefully acknowledged. Especially noteworthy are the contributions of Marilyn S. Smith, Special Assistant to the Director of Energy Research, and Drs. John Ireland and Glen Graves of the Los Alamos National Laboratory.

For the most part, it was necessary for the consultants to carry out their activities in parallel with the various Departmental review groups. The N-Reactor Technical Safety Appraisal Report was issued in late July and the Design Review Report in early September. The definitive technical information on the Chernobyl accident was released by the Soviets in late August. The findings by this consultant are based on the above noted reports and other information obtained from common briefings, discussions, and available reports. Especially valuable was the participation of, and the opportunity to exchange views with, the other consultants appointed by the Secretary of Energy, namely Dr. Miles C. Leverett, Prof. Harold W. Lewis, Prof. Thomas H. Pigford, Mr. Louis H. Roddis, Jr., and Admiral (Ret.) Eugene P. Wilkinson. The conclusions and recommendations contained herein are this consultant's (GFT) sole responsibility.

In the material that follows, the attempt will be made to differentiate between safety issues that relate to prevention of a major accident in the first instance and those that relate to mitigation of the consequences should an accident occur. Further, a more narrow approach is taken than that in the Technical Safety Appraisal by addressing only nuclear safety related issues and not industrial and worker safety, unless such might be contributing factors to a major nuclear accident.

Chernobyl

A first order of business for the consultants was to determine and understand the design features of the RBMK and to compare them with the N-Reactor. This was done by reviewing documents and receiving briefings from U.S. experts who had studied the design (see Appendix). There are a number of very important safety-related differences, some of which played a major role in the Chernobyl accident. These have been documented in the Design Review of the N-Reactor (see section 8.0). Significant differences providing inherent safety advantages for the N-Reactor include:

o Negative void coefficient,
o Horizontal process tubes,
o Graphite and shield cooling,
o Two independent scram systems, both fast, and
o Shutdown during refueling.

At a relatively early time following the accident, the Soviets disclosed the fact that a test was underway at the time of the accident; the details became clear during the August IAEA Vienna meeting. It is difficult to comprehend the circumstances, including disabled safety systems and disregard of the RBMK's operating sensitivities, that permitted the test to be made.

There are, however, lessons to be learned. From Chernobyl and from Three Mile Island, the message is that if a major accident happens, it is likely to result from an unanticipated scenario and to involve steam and/or hydrogen. Thus the problem is how to prevent the unanticipated from becoming a severe accident and how to achieve mitigation, that is, controlling steam and/or hydrogen to the extent necessary to maintain the integrity of confinement or containment systems.

The DOE Reviews

Three DOE review reports have been issued. The first, a quickie review by the Special Safety Team, examined graphite fire and confinement issues. The principal recommendations were directed at questions of hydrogen generation and control and at operational reliability of the confinement system. These are more fully addressed in the Technical Safety Appraisal and Design Review Reports and will not be discussed at this point.

Technical Safety Appraisal of the N-Reactor (July 1986)

The report concludes that "No indications were found that a serious accident is likely to occur at N-Reactor, or that contractor employees or the general public are being subjected to unacceptable risks." The review team offered 51 recommendations directed toward enhancement of safety.

The report makes a good start in categorizing the various recommendations which cover all aspects of safety from normal to accident conditions. None was found to be in the nature of a deficiency that might compromise safe operation of the reactor.

This consultant finds the work of the Technical Safety Appraisal Team extensive and satisfactory. One must bear in mind that its charge goes beyond the narrowly defined one of reactor safety. It does emphasize a concern for complacency, a common problem facing operators of established high technology endeavors that have had a long record of successful operation. To the extent that there exists a laissez-faire approach in normal industrial safety areas, one must be concerned about a carry over to nuclear safety matters. Continuing attention is needed to overcome and prevent complacency.

Because of the variety of objectives covered by the 51 recommendations, establishment both of priorities for their implementation and of an action plan are necessary.

Design Review of N-Reactor (September 1986)

The Design Team concluded that "..the N-Reactor is safe to operate and that there is no reason to stop or alter its operation in any major respect at this time." Certain additional analyses and testing are recommended to provide a firmer basis for decisions on long-term operations. Fifty-two recommendations have been made by the Review Team. These are categorized, for the most part, within eight areas and listed in section 1.4 of the report. Several can be described under accident prevention, e.g. pressure tube surveillance and replacement, graphite and shield cooling, redundancy for ECCS coolant, while others can be described under mitigation of consequences, e.g. confinement testing, environmental qualification. The recommendations to expedite and extend the probabilistic risk assessment (PRA) to a full scope level-3 and to upgrade analytical capability, especially best-estimate calculational capability, will better serve to identify serious risks in both categories.

This consultant finds the work of the Design Review Team to be exhaustive and well done. The key issues have been addressed and where information is incomplete or inconclusive, or analyses less than thorough, additional work has been recommended. However, as with the Technical Safety Appraisal recommendations, priorities and an action plan need to be established.

Early in September, the Under Secretary was provided with a cummulative analysis of ESH reviews. This is a good first step in preparing an action plan. The consultants have been advised that such a plan is under development.

Chernobyl-Lessons Learned

1. It is this consultant's opinion that a Chernobyl-type initiated accident cannot happen at N-Reactor. Existing management policies and operations practices preclude carrying out the type of test that initiated the accident sequence at Chernobyl. Although graphite is common to the two reactors, it did not participate in the accident. Safety-wise, the design features and operating conditions of N-Reactor are far superior to those of the RBMK.

2. Chernobyl and Three Mile Island have demonstrated that for the severe accidents that did happen, the initiating event was unanticipated, that is,it was not previously treated as credible.

3. Given the possibility of an unanticipated major accident at N-Reactor, the seriousness of the consequences will most likely be governed by the presence of steam and hydrogen and the ability to control high pressures and/or prevent explosions in the confinement space.

Accident Prevention at N-Reactor

Credible accident scenarios have been examined in detail and designs and operating procedures established to prevent them.

1. What special measures then, can be adopted to prevent the unanticipated?

- Professional training and education carried out at all levels on a continuing basis, especially education to enable supervisors to respond quickly and responsively to the unusual or unexpected.

- Quality maintenance and especially surveillance of aging components along with a positive replacement program (process tubes, graphite.)

2. N-Reactor has been operated safely for over 20 years. A new generation of managers and operators has replaced the original designers, builders, and operators. Success can breed complacency. The hi-tech nature of reactors cannot tolerate complacency in either operations or maintenance.

Mitigation of Consequences

Chernobyl and Three Mile Island demonstrated that the most significant factors effecting mitigation of consequences were control of high-pressure steam and of hydrogen and control of release of radioactivity to the environment. At Chernobyl, steam and/or hydrogen explosions destroyed their ability to control the release of radioactivity.

1. Hydrogen generation under accident conditions has been examined for the N-Reactor, but there remain some uncertainties that require further investigation.

2. The N-Reactor confinement has been designed to provide for controlled releases to the environment under accident conditions. There remain major questions as to whether, after 20 years of reactor operation and no opportunity for a true system test, all components of the confinement system would indeed operate as designed and programmed. Continuing surveillance and tests of vital components are necessary.

General

1. Public perception, whether factually correct or not, is important. Confinement can be an acceptable method of mitigation; however, containment tends to be perceived by the public as superior. The NRC requirement of containment for nuclear power reactors reinforces that view. In a similiar way, "licensing" by a body independent of the plant owner-operator is perceived as a more safety-credible process. While DOE has taken steps in this direction by establishing ESH, DOE remains both owner-operator and regulator of the N-Reactor.

2. DOE lines of authority and responsibility are multi-layered, long and complex. At Headquarters there are two independent organizational units, Defense Programs (DP) for N-Reactor "operations" and Environment, Safety and Health (ESH) for "regulation," each reporting to the Under Secretary. There is a similar structure at the field office level where the Manager has parallel groups. Yet, the day-to-day operating responsibility is with the contractor. The chain is long, complex, and burdened by too many people.

3. The several DOE review teams have concluded that operation of the N-Reactor is safe, but then offer many recommendations for enhancement. These need to be put

in context and prioritized. Early establishment of an action plan will put them in perspective and indicate the seriousness of DOE's and the contractor's attention to safety. It is understood that a plan is under development; however, DOE will be judged by the decisions made, timely funding, and early effective implementation.

Conclusions and Recommendations

The work of the DOE Review Teams has been comprehensive. No deficiencies have been uncovered that would mandate immediate shut down of N-Reactor for corrective action.

I. The recommendations, which are now being prioritized and for which an action plan is being developed, generally are directed toward investigations, analyses, operational improvements, and equipment and facility changes that are required for the near- term safe operation. Many, of course, would serve longer term requirements. It is recognized that several very major changes, e.g. replacement of graphite and process tubes, would be required in the N-Reactor plant, if operation into the 21st century is to be achieved. The timing for such major reconstruction is uncertain. If future defense production requirements are such as to require the equivalent of an N-Reactor on-line after the mid-nineties, they should be met by a new production reactor and not a rebuilt N-Reactor. Finally, a decision now, not to rebuild the N-Reactor will facilitate decisions and actions required to meet near-term safety needs.

Recommendation: DOE should decide now that the safety enhancement program for the N-Reactor will be directed toward its continued operation for the next 5 to 10 years and that its operational life will not be extended beyond its "natural life."

II. The Review Teams have made a large number of recommendations. They encompass a range from nuclear reactor specific to industrial safety issues. Many can be implemented by the contractor in the normal course of operations and maintenance. Others will require DOE actions such as authorizing extended shutdowns to accommodate changes, testing, replacements, etc., funding of urgent investigations and studies by UNC and others, and funding for equipment and facility changes and additions.

Recommendation: In conjunction with the contractor, prioritize the numerous recommendations with respect to implementation and, on an urgent basis, establish and fund action plans consistent with N-Reactor operations for the short term.

III. The basis for approval of the operation of the N-Reactor is the NUSAR. Assumptions are based on a combination of experimental facts, theory, analyses, and experience. In the course of the DOE reviews, especially the Design Review, and the Consultants' Reviews, questions have been raised concerning some of the assumptions adopted. The Chernobyl accident has certainly focussed attention on hydrogen generation and control. Although a probabilistic risk assessment (PRA) is under way, the questions raised have underscored the value of extending it to include all levels, i.e., PRA-2 and -3.

Recommendation:

A. Re-evaluate the generation and control of hydrogen under accident conditions. Investigate the methods of prevention of build-up of explosive mixtures and detonation, for example, controlled burning, recombiners, inerting.

B. Expedite and expand the PRA analysis. The contractor should be intimately involved, but the magnitude of the task and the urgency requires responsibility to be assigned to one organization with the authority to draw on the resources of other groups on an expedited basis. Some questions cannot wait for the PRA results and should be addressed in the interim on a best-estimate basis.

IV. Confinement is the key to mitigation of off-site consequences. Effective operation of the confinement system as designed and programmed is necessary. To achieve this, the elements of the system must function properly and, to do so, must first of all be protected from damage by the accident itself. It is recognized that a full systems test of the confinement system is not possible. However, after 20 years, uncertainties have developed. The Review Teams have recognized these and made recommendations.

Recommendation:

A. Analyze and test each component and sub-system of the confinement system to the maximum extent feasible to ensure its proper operation.

B. Re-evaluate the expected chemical forms and quantities of iodine release and the effectiveness of the spray and filter systems in their removal.

V. Accident prevention in the short term must focus on the hands-on on-site response of reactor operators and the proper maintenance of equipment. Training is focussed on the handling of credible accident scenarios. Broader education is required for those whose responsibility it is to make rapid decisions when the unusual or unanticipated event occurs. On the maintenance side, assurance of quality-reliable operation is the objective. It is recognized that process tube failures and graphite growth can be major problems in the next five to ten years. Surveillance to prevent failures is mandatory.

Recommendation:

A. Emphasis must continue on the training function including conforming manuals and simulator performance to actual control room conditions and reactor behavior.

B. Continue to strengthen through education the on-site control room capability to respond to unusual and unanticipated events.

C. Maintain a vigorous surveillance and replacement program, especially with regard to process tube failure and graphite growth.

VI. The review teams identified several situations where separation of safety support equipment or provision for remote operating capability would enhance safety under accident conditions. Some of these projects are now under way, for example, a remote shutdown and monitoring capability.

Recommendation: DOE must facilitate design, funding and construction of identified support equipment where changes are recommended in the interest of reducing vulnerability.

VII. DOE has carried out the present reviews under the direction of the Assistant Secretary for Environment, Safety, and Health. The review teams were composed of experts from the Department of Energy, its contractors, and others. Although the team members are experienced and capable and are separated from Defense Programs, which is responsible for the N-Reactor, the reviews are looked upon by outsiders as an "in-house" operation. The Department should avail itself of peer review services of external "institutions."

Recommendation: DOE should make greater use of external peer review groups to address reactor safety on a continuing basis. The use of external entities such as ACRS and INPO should be pursued.

Concluding Comments and Observations

The specific Chernobyl-4 accident scenario has little relevance to N-Reactor safety consideration. Fundamental differences in design coupled with management and operations policies, regulations, and procedures would have precluded such a test from being carried out at the N-Reactor.

The Chernobyl accident did stimulate DOE and others to carry out extensive reviews of N-Reactor safety. The accident also reinforced TMI-2 findings that the serious accidents that happen are in the category of the unanticipated and are likely to involve hydrogen generation. Thus, to lower the risk of an accident actually taking place, more attention needs to be given to understanding and coping with the extremely low probability, but potential, unusual event. If the accident does occur, more attention needs to be given to preserving the credibility of the confinement/containment system. Here, hydrogen and steam play major roles.

The DOE reviews taken collectively were detailed and comprehensive. They were objective and carried out by qualified persons. Items that require further analyses, change of procedures, equipment modifications or additions are identified. It is understood that an action plan is under development.

The N-Reactor went on line in 1963. The added risk to the public was evaluated as being a very small increment compared to that due to the presence of the other materials production reactors then operating at Hanford. The largest operating reactors of that period were for defense production; power reactors were in the early stages of scale up to larger units. Today, operating reactors are dominated by the power generators, and regulation is by an independent oversight body, the Nuclear Regulatory

Commission (NRC). Comparisons tend to be made now with NRC regulations. The absolute risk of occurrence of an accident due to operation of the N-Reactor is less today than in 1963 because of the wealth of experience gained and the safety upgrades that have taken place in the intervening years.

In looking to the future, the N-Reactor is an aging reactor. One can expect components to fail and to require replacement. One must be assured that such failures are fail safe. The N-Reactor has some unique features such as graphite that undergoes volumetric changes with continued irradiation. There are limits to what changes can be tolerated. Replacement of the graphite and the process tubes (fuel channels) has been proposed. If material production for national security purposes is required of the N-Reactor beyond say 1995, a new production reactor should be constructed. Heroic measures should not be taken to extend the "natural life" of the N-Reactor.

To conclude, it is this consultant's overall opinion that:

- The risk of a major accident at the N-Reactor is comparable to that of a commercial power reactor.
- The risk of consequences to the public from a major accident must be assumed to be higher than from a commercial power reactor because of uncertainties in the control of hydrogen and the effectiveness of the confinement system under accident conditions.
- Assuming a continuing requirement for the production of nuclear material from the N-Reactor for national security purposes, these risks are acceptable.
- Implementation on an urgent basis of the prioritized recommendations of the review teams will contribute to the reduction of present risks and is prudent.
- A decision is needed on the future of the N-Reactor now, preferably one supporting operation for 5 to 10 years followed by permanent shutdown.

September 30, 1986

APPENDIX

1. John S. Herrington, letter to Gerald F. Tape (May 2, 1986).
2. "Herrington Asks Experts to Assist in Reviewing Safety of Department's N-Reactor," DOE News release, May 5, 1986.
3. "Herrington Fills Out Expert Consultant Panel Reviewing N-Reactor," DOE News release, May 7, 1986.
4. Biography for Gerald F. Tape.
5. Schedule of Joint Briefings.
6. Bibliography
7. N-Reactor and RBMK Comparison.

UCB-NE-4089

Chernobyl and the N-Reactor at Hanford

A Report To

John L. Herrington, Secretary
United States Department of Energy

by

Thomas H. Pigford
Berkeley, California

October 6, 1986

INDEX

Page

1. SUMMARY 1

2. CHARGES TO THE CONSULTANTS 2

3. STANDARDS FOR ASSESSING N-REACTOR SAFETY 3

4. DIAGNOSIS OF THE CHERNOBYL ACCIDENT 3

5. LESSONS LEARNED FROM CHERNOBYL 5

6. THE N-REACTOR CONFINEMENT SYSTEM 6

    6.1. Functions and Issues 6

    6.2. Source Terms 6

    6.3. Hydrogen Generation and Mitigation 8

    6.4. Removal of Radioactivity 11

    6.5. Confinement of Liquid Discharges 13

    6.6. Confinement Emergency Procedures 13

7. PRESSURE TUBES 14

8. ON-LINE SAMPLING OF PRIMARY COOLANT WATER 14

9. PROBABILISTIC RISK ASSESSMENT 14

10. THE MANAGEMENT OF NUCLEAR SAFETY 15

11. FINDINGS 15

12. RECOMMENDATIONS 17

13. ACKNOWLEDGMENTS 18

14. REFERENCES 19

APPENDIX A. Questions to the U.S. Department of Energy on the Chernobyl Accident 20

APPENDIX B. Comparison of Chernobyl and N-Reactor Design 21 - 29

1. SUMMARY

The reactor accident at Chernobyl tells us again, as at Three Mile Island, that unanalyzed and unforeseen accidents can happen, from design or operator error or both. Relying on a specified design-basis accident is not sufficient to assure safety. Accident analysis should include accidents involving operator error and severe core damage.

The N reactor at Hanford cannot"experience a severe power-excursion accident of the type that occurred at Chernobyl. However, the Soviet accident focuses on issues that are relevant to the safety of the N reactor, including the need for adequate containment or confinement of radioactivity that can be released in a severe accident and the need for close attention to training, procedures, and management of nuclear safety.

Uncertainties in the technical basis for predicting performance of the N-reactor confinement system now question the level of safety that was concluded in the 1978 safety review of the N reactor. Also, the N reactor does not meet some of the tighter standards of safety that have evolved in the commercial nuclear industry after the accident at Three Mile Island.

It is recommended that the Department of Energy give high priority to the following:

1. Determine the standards for risk and safety for the N reactor that are justified by the benefits from operating the N reactor.

2. Resolve the uncertainties in performance of the N-reactor confinement system.

3. Install a hydrogen-mitigation system for the N-reactor confinement. Calculate local concentrations of hydrogen in the confinement compartments to aid in designing the hydrogen-mitigation system.

4. Install a confined basin or tank to contain radioactive liquids that will be pumped from the confinement during an accident.

5. Update the 1978 safety analysis of the chemical form and amounts of fission products that will be evolved from overheated fuel during severe accidents.

6. Extend the safety analysis to include accidents that can develop higher fuel temperatures, larger quantities of hydrogen, and different chemical and physical forms of fission products released from overheated fuel, including accidents involving equipment failure and operator error.

7. Re-evaluate the performance of the radioactivity removal system that is part of the N reactor confinement.

8. Develop realistic predictions of confinement performance symptoms to aid training and emergency procedures.

9. Arrange for the N-reactor operating organization to become an active information-sharing participant with the Institute of Nuclear Power Operations (INPO), to implement the safety-management practices established for the commercial reactor industry, to have its training program accredited by the National Academy for Nuclear Training, and to be audited periodically by INPO. "

These recommendations for near-term action should not await the more lengthy formalism and completion of a probabilistic risk assessment that will take at least a year.

It is also recommended that the Department of Energy sponsor more detailed safety analysis to better understand and to learn from the reactor accident at Chernobyl.

2. THE CHARGES TO THE CONSULTANTS

On May 7, 1986, shortly after the reactor accident at Chernobyl, Secretary of Energy John L. Herrington requested six consultants to review safety issues of the N-reactor at Hanford, Washington. The charges to the consultants were [1]:

> "The consultants will review the facts and findings surrounding the Soviet reactor accident at Chernobyl.
>
> Based on these facts and findings, the consultants will examine N-reactor operations and safety procedures to ensure that all key technical questions and potential safety issues raised by the Soviet accident have been considered.
>
> The consultants will also examine the information and findings developed by the Department's safety reviews of the N-reactor to ensure that the relevant facts and findings from the Soviet accident have been addressed by the review teams."

On May 23, 1986 Under Secretary Salgado asked the consultants to also address the following questions:

> "Are all important issues being adequately addressed?
>
> Is the N reactor being operated safely?
>
> Can the N reactor be operated safely?"

Each consultant was requested to submit an individual report.

3. STANDARDS FOR ASSESSING N-REACTOR SAFETY

The charges and questions to the consultants require us to assess the safety adequacy of several features of the N reactor. To reach a finding on adequacy of safety requires a standard of what level of safety is adequate. The standard used herein is that specified by the 1978 updated safety analysis of the N reactor [2], referred to as the NUSAR. Also, new safety issues that affected the analysis of commercial-reactor safety emerged after the reactor accident at Three Mile Island and were reinforced by the Chernobyl accident. Many of the post-TMI safety issues are relevant to the N reactor and imply additional standards of safety that were not fully considered in the 1978 NUSAR review. Congressional testimony by Department of Energy officials after Chernobyl and portions of the Department's recent technical appraisal reports on N-reactor safety suggest that some of these new commercial-reactor safety issues should be considered for the N reactor, as is done herein. Consequently, the standards being applied to N-reactor safety are more restrictive than those adopted for the 1978 safety review.

There is no determination here of whether risks of N-reactor operation are balanced by the benefits from that operation. The consultants have not received or sought information on benefits from weapons production, so we have no basis for reaching a finding on N benefits and risks. Therefore, there is no basis for a consultant finding on whether risks from N should be acceptable. The determination of whether benefits justify the risks should be made by the Department of Energy.

4. DIAGNOSIS OF THE CHERNOBYL ACCIDENT

The reactor accident at Chernobyl resulted in part from the reactor operating under conditions where nuclear reactivity increases when liquid water in the reactor turns to steam, i.e., a positive void coefficient of reactivity [3]. The void coefficient is reported to become negative in the region of high steam content [4]. When the reactor was operating at low-power for a turbine coast-down experiment with some safety systems improperly disengaged and the reactor coolant channels nearly filled with liquid water, improper operator actions caused water to boil, the nuclear reactivity and heat-generation rate increased, more steam was formed, and the reactor quickly generated enormous power and steam pressure until finally terminated by excessive heating of the fuel and more extensive steam voiding. The steam explosion ruptured pressure tubes and blew off the top lid that isolated the reactor compartment from the building atmosphere. The N reactor has a negative void coefficient over its entire range of operation, so this type of nuclear runaway cannot occur.

The design error of the positive void coefficient was compounded by operator error, inadequate procedures, an inadequately designed containment, and the generation and explosion of hydrogen of hydrogen from reactions of hot zirconium metal with water and steam. These are issues relevant to the N reactor, although the details in which they could become involved in an accident are not the same at N as at Chernobyl.

The importance of graphite in the Chernobyl accident is not clear. Pieces of burning graphite ejected from the reactor contributed to the building fire, and hot graphite in the reactor burned and contributed to continued but slower release of radioactivity after the first explosions. Graphite burning does not appear to have been a root cause of the Chernobyl accident, and it seems unlikely to be a significant safety issue at the N reactor as long as the N confinement system remains intact. Graphite may have kept the Chernobyl reactor fuel from melting down to the bottom of the reactor, and it would be expected to act similarly at the N reactor.

The potential for graphite to react with hot water and steam to absorb heat and to generate hydrogen and carbon monoxide may not have been important in the Chernobyl accident, and it does not seem important at the N reactor.

The DOE Design Review Team [5] points out that the fuel channels in the Chernobyl reactor are vertical and that those in the N reactor are horizontal, and it projects greater safety from horizontal channels, on the basis that vertical channels promote more rapid hydrogen generation and that there will be less buoyancy-driven air flow in horizontal channels if air reaches the hot reactor. The suggestion is plausible, but no analysis is provided by the Design Review Team. The overall flow pathway, with its resistances and elevation changes, would have to be considered. For accidents that involve overheated fuel and metal-water reactions, the possibility of slugs of water reaching the dry overheated fuel in horizontal channels, such as by operator error, should be considered. The vertical channels in the N reactor for the backup control absorbers should also be considered.

These are the principal Chernobyl issues that are considered in this N-reactor review. There are many other design differences between the Chernobyl and N reactors, and there are many other Chernobyl issues, such as emergency response, that could be issues at the N reactor, but they are not considered in this report.

An overriding observation from the Chernobyl accident is that the design-basis accident is not necessarily the worst accident that can happen. Serious and unexpected accidents can happen, involving design and operator errors. At Chernobyl the condition to initiate the rapid transient and explosion was approached slowly, with ample time for operator reflection and correction. The same was true for the accident at Three Mile Island. If events are allowed to proceed uncorrected, a delicate condition can be reached wherein severe damage can occur rapidly and uncontrollably, as in the reactivity transient and steam explosion at Chernobyl and the rapid reaction of steam with zirconium metal at Three Mile Island. Some of these unexpected accidents can be anticipated by more thorough analyses of events, including those involving operator error, that can lead to accidents. These experiences also argue for adequate post-accident mitigation systems to protect against the accident that has not been planned for, such as adequate containment or confinement of released radioactivity. The adequacy of the N confinement system is a focus of this review.

It is clear from the Soviet report [3] of the Chernobyl accident and from the August meeting in Vienna that the events that occurred during the steam explosion and the following hydrogen explosion are poorly understood. It is these details that will be most helpful in identifying technical lessons learned at Chernobyl and applying them, where relevant, to the N reactor and to other U.S. reactors. However, the U.S. has done too little to study and diagnose the chernobyl accident in a way that can benefit the U.S. reactors, a far cry from the active and thorough diagnostic studies by government and industry after the accident at Three Mile Island.

No answers have been received to the consultant technical questions (see Appendix A) provided to DOE officials and to an IAEA representative in June. Little has been done in response to consultant recommendations in July that the U.S. initiate its own study to answer these and other questions on Chernobyl.

Individuals who have performed some Chernobyl analyses report that there has not yet been a successful U.S. calculation of the void dependence of the void coefficient of reactivity reported by the Soviets [4], although it is thought that the Chernobyl calculation may be correct. The Chernobyl incident provides an opportunity to verify U.S. calculational techniques. The little progress points out that too little U.S. effort has been applied to diagnosing Chernobyl.

Better understanding of the Chernobyl design and its accident, calculation of reactivity changes from steam formation, calculation of control worth and spatial power instabilities, mechanisms of pressure-tube failure, propagation of pressure-tube transients and failures to adjacent pressure tubes, transient heat transfer to and from graphite during a severe accident, and interaction of steam with zircaloy and graphite, is essential to our learning the technical lessons from Chernobyl and applying them to U.S. reactors. A DOE-sponsored program to do such analyses is again recommended.

5. LESSONS LEARNED FROM CHERNOBYL

We learn from the reactor accident at Chernobyl, and from the earlier accident at Three Mile Island, that:

1. Relying on a specified design-basis hypothetical accident to assure safety is insufficient. The unanalyzed accidents can happen, from design or operator error or both, a lesson learned earlier at Three Mile Island.

2. Accident analysis should include accidents involving operator error and accidents involving severe core damage.

3. Adequate confinement or containment is needed to protect the public from radioactivity released in a serious accident.

4. Containments and confinements need to be protected against hydrogen explosion or detonation.

5. Good safety practices, implemented by operators and plant management, and subjected to independent audit, are necessary to avoid complacency, to ensure that accidents are prevented and mitigated, and to reduce the likelihood that the unplanned-for accidents will happen.

6. THE N-REACTOR CONFINEMENT SYSTEM

6.1 Functions and Issues

The function of the N confinement system is to prevent radioactivity from escaping to the surroundings. The confinement system consists of the reactor building and coupled auxiliary buildings and compartments that are protected against appreciable internal pressures by quenching and venting the steam expected to be released in the early stages of a severe accident. The design depends on a time delay between steam release and the later release of radioactivity. After the vents close, most of the radioactivity released from a severe core accident is expected to be removed by the fog spray system and filters. Some contaminated air can reach the atmosphere by building leakage.

There is no fundamental reason why a vented confinement system cannot be designed and operated to the same degree of protection and reliability as the nonvented containments of the U.S. commercial reactors. However, Chernobyl, TMI, and commercial reactor containment criteria focus on the adequacy of the N-reactor confinement design. Issues considered here are the possibility that hydrogen generated during an accident will explode and destroy the confinement structure, the adequacy of the design for radioactivity removal, the potential danger from storing accident-generated radioactive liquids in a crib outside the confinement, and the adequacy of the information available to train operators in emergency procedures to protect the N confinement. The ability of the confinement to function depends in part on the time interval between the vented steam release in an accident and the release of hydrogen and radioactivity; it also depends on the amount and rate of release of hydrogen and the amount, rate, and chemical and particulate forms of the released radioactivity.

6.2. N-Reactor Source Terms

The hypothetical accident that is the design basis for the N confinement assumes the rupture of a single Zircaloy pressure tube, automatic shut down the reactor, and failure of the emergency cooling system to operate. After the rapid initial depressurization by steam and water escaping to the confinement, the fuel heats up more slowly than would occur in a commercial light-water reactor or in a Chernobyl-type reactor undergoing a similar transient, because of the high thermal conductivity and low stored energy of the N-reactor metallic uranium fuel and heat transfer from the hot fuel through the pressure tube into the graphite. Even though the thermal-diffusion time constant for heat to transfer to the graphite cooling system is estimated to be as long as 18 minutes, the transient proceeds slowly enough that the graphite cooling system aids in limiting the temperature rise to about 1200°C, and it provides a long-term heat-removal system that prevents further heating of the reactor core. The calculated temperature rise is also limited by the N designer's belief that hot uranium in the central fuel cylinder will expand to contact the outer tube, so that it is cooled by conduction and blocks the flow of steam that would otherwise react and generate hydrogen and heat in this central region. The maximum fuel temperature of 1200°C is predicted to occur several minutes after the beginning of the accident. About a third of the uranium-metal fuel is predicted to melt, but the Zircaloy cladding and and all other Zircaloy pressure tubes are predicted to remain intact.

In this hypothetical accident the Zircaloy fuel cladding never reaches the threshold level of about 1500°C wherein the steam-water reaction would be so rapid that heat generated by the chemical reaction results in autocatalytic heating and temperature rise, accompanied by near complete reaction of zirconium with any steam that reaches the hot fuel. Such high temperatures and large hydrogen releases are predicted for water-cooled uranium-dioxide-fueled reactors with loss of coolant and no emergency cooling, as occurred in the accidents at Three Mile Island and Chernobyl. Because of the limited temperature rise predicted for the N reactor, the calculated hydrogen generation is low, only about 850 cubic meters, about 0.5 percent of the potential hydrogen generation for this reactor. This compares with about 5500 cubic meters estimated to have been generated in the Three-Mile Island accident, about 50 percent of the potential hydrogen generation for that reactor.

The NUSAR calculations are competently done, but the calculated maximum temperature is close to the threshold temperature for autocatalytic zirconium-water reaction, thereby questioning the assumption that this hypothetical accident is a suitably severe accident scenario to serve as a basis for confinement design. There should be careful scrutiny of the assumptions that are inherent to the NUSAR hypothetical accident, such as no more than one failed pressure tube, no propagation of pressure-tube failure to adjacent pressure tubes, good heat conduction from the central fuel cylinder, and no flow of steam oxidant to the inner surfaces of the fuel. Thus, pressure tube integrity, a problem that is being addressed at the N reactor, becomes of paramount importance in severe accident analysis. The possibility of less efficient cooling of the inner fuel surfaces and intermittent flow of water oxidant to the hotter inner fuel surfaces should be considered, as well as improper operator response that could introduce water into overheated fuel channels. If higher temperatures and more rapid heating transients can occur, cooling by heat conduction to the surrounding graphite and to the graphite coolant will be less effective in limiting the maximum temperatures and fuel damage in the severe accidents.

6.3. Hydrogen Generation and Mitigation

The N safety analysis report [2] and the Design Review Team [5] conclude that hydrogen released to the N confinement building during the hypothetical accident, the most severe accident considered, will not be an explosion hazard because the hydrogen will be well mixed with all air in the interconnected confinement compartments and will not reach explosive concentrations. However, hydrogen generated in a severe accident is expected to be released at high concentrations. At some locations in the confinement volume hydrogen concentrations that can support deflagration or detonation must be expected. Even if the hydrogen were highly diluted by unreacted steam in the reactor, condensation of steam by the fog spray and inleakage of air can result in the formation of deflagratable and detonable concentrations of hydrogen. The issue is what transient concentrations of hydrogen can be reached in what volume of gas, and what damage can result from the combustion of this hydrogen.

Contrasted to the large containment volumes of most commercial pressurized-water reactors, the N-reactor confinement could not survive the pressure increase if an appreciable quantity of hydrogen were to explode, i.e., deflagrate or detonate. The exhaust filters are specially vulnerable. Therefore, the N safety managers must demonstrate that the rapid mixing assumed in the NUSAR actually occurs without local explosion or detonation. The unfounded NUSAR assumption of rapid and complete mixing without explosion or detonation means that the risk from operating the N-reactor can be greater than concluded in the NUSAR analysis. The uncertainties in the containment hydrogen issues are unacceptable and should be resolved with highest priority. There is no reason to wait for the completion of the probabilistic risk assessment, about a year away, to resolve the hydrogen issues. The issues are well defined and can be—and should be—addressed directly and expeditiously.

The N-reactor operator, UNC Nuclear Industries, has recognized the importance of the hydrogen issue and has already commissioned contractor studies to calculate transient concentrations of hydrogen in the confinement compartments, to determine if explosive or detonable concentrations could occur. Results recently obtained from a "lumped-parameter" calculation, that assigns subcompartments and assumes instantaneous and complete mixing in each subcompartment, predict temporal concentrations greater than that calculated in NUSAR. No explosive concentration is predicted when the hydrogen is assumed to be released from a break in the pipe gallery [6]. A deflagration concentration is predicted when the release is in the reactor building, but no damage is predicted, evidently a result of the limited volume of exploding gas. Other locations of the pipe break can give different results and need to be examined, such as the penthouse located above the spray nozzles.

Even when lumped-parameter calculations predict no hydrogen burning, there remains the possibility of damaging deflagrations or detonations within the compartment in which the hydrogen is released. There is DOE capability [7,8] to make the more detailed field calculation that does not rely on the assumptions of instantaneous mixing in compartments that are necessary for the lumped-parameter calculations. It was the expectation that such calculation needed to be done and could be completed during the tenure of the consultants that was one motivation for the consultants' written [9] and oral recommendations to DOE in July that high priority be given to resolving the N-reactor hydrogen issues and other confinement issues. However, the field calculation that could answer the question of hydrogen burning has not yet been authorized.

Whether hydrogen can reach concentrations sufficient to explode and destroy the N-reactor confinement depends also on the amount and rate of hydrogen generation. The NUSAR analysis of the hypothetical accident predicts only about 850 cubic meters of hydrogen from zirconium-water reactions, about 0.5 percent of the potential amount that could be formed if all of the zirconium and uranium were to react with water or steam. In comparison, about 50 percent of the zirconium reacted to form hydrogen at Three Mile Island, and containments of commercial reactors are required to be protected against the release of 75 percent of the hydrogen that could potentially be formed. Further, the amount of hydrogen that could potentially be formed in the N reactor is greater than that at Chernobyl, over threefold greater than in a commercial boiling-water reactor, and about sixteenfold greater than in a commercial pressurized-water reactor. These comparisons are shown in Table 1.

At some amount and rate of hydrogen generation, only about fourfold greater than predicted in the NUSAR accident, deflagratable concentrations of hydrogen in the N confinement would occur even if the hydrogen were instantaneously well mixed with all of the confinement air. Even greater quantities of hydrogen can be produced in the more severe accidents that should be considered.

The NRC requirement that commercial plants protect against 75 percent of the potential hydrogen is not a result of accident analysis. It is a nonmechanistic criterion, similar to the nonmechanistic 10 CFR 100 requirements that commercial containments protect against the release of all of the noble radioactive gases, 50 percent of the radioiodine, etc. The 10 CFR 100 criterion has already been adopted in the NUSAR analysis. The NRC's new hydrogen-protection requirement illustrates the evolution of tighter standards for commercial reactor safety. Another example is the NRC requirement for analyzing more severe reactor accidents than considered in earlier safety analyses. If the N reactor is found wanting under these new standards of commercial reactor safety, it does not mean that N is necessarily of greater risk than earlier perceived. It only means that N has not kept pace with the commercial safety requirements. The Department of Energy should determine to what extent these new commercial-reactor safety requirements should be required for the N reactor.

Containment buildings for some commercial reactors could not withstand

Table 1. Amount of Hydrogen from Metal-Water Reactions

	N Reactor	Chernobyl	Commercial pressurized water reactor	Commercial boiling water reactor
Amount of zirconium				
Fuel cladding, kg	14,800	74,000	21,000	32,600
Pressure tubes, kg	178,000	103,000	0	60,500[a]
Total	192,800	177,000	21,000	93,100
Amount of uranium metal, kg	365,000	0	0	0
Potential amount of hydrogen, cubic meters[b]				
From zirconium	102,000	93,500	11,100	49,200
From uranium	74,000	0	0	0
Total, m^3	176,000	93,500	11,100	49,000
Hydrogen released in accident				
Amount, m^3	850[c]	unknown	~ 5,500 (TMI)[d] 8,300 (NRC)[e]	36,900 (NRC)[e]
Fraction of potential	0.0048[c]	unknown	~ 0.5 (TMI) 0.75 (NRC)	0.75 (NRC)

a/ In fuel channels
b/ Cubic meters at 0^oC and 1 atm
c/ N-reactor hypothetical accident
d/ Estimate for accident at Three Mile Island
e/ NRC criterion for commercial-reactor containment

explosion of the assumed release of 75 percent of the potential hydrogen. They are protected by inerting the containment compartments or by burning the hydrogen soon after it is released. Such mitigation techniques should be considered and evaluated for the N reactor. Present information is not sufficient to determine what hydrogen mitigation technique will be feasible and practicable.

6.4. Removal of Radioactivity Released to the Confinement

Fog sprays in most of the N-reactor confinement compartments turn on automatically if steam is released to the confinement. The water sprays cool and condense steam released early in the accident. The sprays are designed to absorb radioiodine gas and radioactive particulates released from overheated fuel in a severe accident, expected to be released to the confinement after the vent valves have closed. The sprays are predicted to absorb, wash out, and retain over 98 percent of the fission products released to the confinement. There has been no functional test of the ability of the fog sprays to quench steam and remove radioactivity. Assurance of performance rests entirely on the design analysis.

The only documented design analysis of the N spray system is that contained in the 1978 safety analysis report [2,10]. The design assumed rapid and complete mixing of spray droplets with the gas phase in each compartment, it uses mathematical equations derived for heat and mass transfer to single droplets, and it relies on empirical rate coefficients determined in a single-compartment spray experiment [11] wherein steam, aerosols, and iodine vapor were introduced simultaneously and complete mixing was assumed in deducing rate coefficients.

There are several reasons why the N-reactor confinement sprays may not perform in the way predicted by the NUSAR analysis. The processes of heat and mass transport in a practical spray system are not likely to obey the complete-mixing equations assumed for this design. Experience in the chemical industry shows that the movement of both spray droplets and the adjacent gas phase in a spray system is complex. Single-drop correlations, as relied on in the N spray design, are of limited use in the design of a multiple-drop spray systems [12]. Shortly after spray droplets are formed they move countercurrently to the gas, but after some fall distance they move concurrently with entrained gas. Typically, most of the mass and heat transfer occurs within the first few feet from the spray nozzles, rather than being distributed uniformly throughout the compartment as assumed in the N design. Spray heads located at various heights in the compartments, as well as covering all of the compartment cross section, would be necessary to achieve the equivalent of complete mixing. Impingement of droplets on walls also affects the extent of mass and heat transport to spray droplets throughout a compartment. Thus, a spray system is simple to construct but complex to analyze. Because of the uncertainty in scaling to other geometries, the chemical industry has generally avoided spray systems and has favored gas-liquid absorption systems that are more predictable.

Although the N design relies on experimental data taken for the same spray-nozzle height as the design, the cross sectional area of the experiment is not the same as in all of the N compartments. Wall effects on mass and heat transport to the spray can be different than implied in the empirical rate constants determined for different lateral dimensions.

The N design assumes that the bulk of the radioiodine entering the confinement is in the form of elemental iodine, and empirical constants obtained for elemental iodine are used in the design analysis of spray removal. The N designers incorrectly interpret early experiments on release of radioactivity from molten uranium in contact with steam at temperatures up to about 1200°C as demonstrating that elemental iodine is evolved. The reference supplied for this review [13] shows that in the absence of oxygen the predominant form of iodine is hydrogen iodide, which will have spray-removal properties different from those of elemental iodine. Oxygen is not expected to present in the reactor during a severe accident, so elemental iodine assumed in the N safety analysis is not expected. Whether hydrogen iodide decomposes to elemental iodine in the confinement and the effect of hydrogen iodide on spray removal have not been analyzed.

For the more severe accidents that should be analyzed for the N reactor, higher fuel temperatures and the presence of hydrogen from metal-water reactions are predicted [14] to result in the release of radioiodine predominantly as a cesium-iodide aerosol, a subject of intense study by the commercial nuclear industry and the Nuclear Regulatory Commission since the accident at Three Mile Island. This would shift the burden of the fog sprays to removing particulate radioiodine.

The N design analysis for removal of particulates assumes that the particle size distribution released to the confinement in an accident is the same as the particle size distribution used in the spray-removal experiment. Removal efficiency is sensitive to particle size. No information has been provided that justifies the design assumption.

The experimental rate data for spray removal of particulates were obtained when steam and particulates were simultaneously injected into a vessel with sprays. Such particles in a saturated steam-air atmosphere absorb water and grow, thereby making it easier for them to be removed. Empirical rate data obtained in this experiment can predict an unrealistically rapid removal rate in the N confinement, wherein particulate radioactivity is expected to be injected well after the steam is released from a pipe break.

The N design analysis calculates the flow of the gas phase from one compartment to another and assumes that radioactive aerosols entering the downstream compartments are of the same size distribution as those assumed to be injected initially into the confinement. Because larger particles are removed more easily by the sprays, subsequent compartments would be expected to receive the particles that are more difficult to remove, so the N design analysis again seems unrealistic.

To verify the design technique and computer code used to predict radioactivity removal by the sprays, the code was used to calculate the results of the single-vessel experiment that provided the empirical data for the design. There is an unexplained discrepancy in the results, and no other tests and checks are described. This is inadequate verification and validation for a design technique important to nuclear safety.

These questions of the design basis for the N spray system were posed to the DOE staff, to the N-reactor staff, and to the Design Review Team early in this investigation. The Design Review team [5] indicates that the adequacy of the N-reactor spray design has been confirmed by other calculations. However, the calculations supplied assume, with no justification provided, complete mixing and single-drop correlations. There is no indication that any of these correlations has been tested against the extensive data in the chemical engineering literature. It is recommended that the design analysis of the N-reactor fog spray system, including any new computer codes that are proposed, be reviewed by the group in the Engineering Services Division, Engineering Department of E. I. du Pont de Nemours, at Newark, Delaware, that is expert on mass transfer in practical industrial systems. Access to this expertise may be possible through the Savannah River Laboratory.

6.5. Confinement of Radioactive Liquid Discharge

Radioactivity removed by the confinement spray system does not remain within the confinement compartments; the radioactive liquid is pumped to an external unlined crib in the ground, at an elevation above the Columbia River. The N safety analysis considers the possibility of volatile radionuclides escaping from this liquid to air, but no analysis has been presented of the possible contamination of ground water and surface water. By exposing this highly radioactive liquid to the environment, the N reactor is no longer confined in the event of a severe accident. Installation of a closed vessel or tank to contain this liquid is recommended. Similar consideration should be given to containing or purifying the radioactive liquids that are normal bleed and leakage from the primary coolant system, though these liquid wastes contain far less radioactivity than is predicted to be present in the confinement spray discharge during an accident.

6.6. Confinement Emergency Procedures

Although the N-confinement system is expected to function automatically, there are times when operator action can be required. If block valves that are closed during periodic calibration tests are not reopened, the sprays will not turn on unless operators recognize the symptoms and open the valves. If a pipe break occurs in one of the steam-generator compartments, operators must read the symptoms and turn the sprays on in that compartment. There are safety procedures to train operators to responding to symptoms expected from the accidents considered in the N-reactor safety analysis. The adequacy of these predicted symptoms is questioned by the uncertainties in the N safety analysis, as discussed above. The emergency procedures should be extended to include the possible symptoms that can appear in the more severe accidents that are recommended for analysis. Possible errors by operators in responding to such symptoms should be considered in the accident analysis.

7. PRESSURE TUBES

The Zircaloy pressure tubes in the reactor are being embrittled by neutron irradiation and hydrogen absorption. The allowable limit on fracture toughness will be reached in about five years. Because pressure-tube integrity is of crucial importance to safety, the effect of embrittlement on pressure tube failure and accident initiation needs careful attention. The program of cold hydro testing is an effective means of monitoring pressure tube integrity.

The N accident analysis assumes guillotine breaks in a pressure tube. Longitudinal splits that have occurred in Canadian pressure tubes can give rise to more severe accident conditions and should be considered in the analysis of severe accidents.

8. ON-LINE SAMPLING OF PRIMARY COOLANT WATER

When constructed, the N reactor had an on-line sampling system to monitor the chemical conditions of the primary water coolant. The system is no longer operable, a result of inadequate maintenance. Water samples are obtained and analyzed manually in a contaminated laboratory wherein operators must wear full protective clothing. Temperature and pressure control equipment for nonradioactive samples is in disrepair. Water chemistry limits are exceeded frequently, resulting in accelerated corrosion and increased personnel exposures. On-line sampling should be restored.

9. PROBABILISTIC RISK ASSESSMENT

A full probabilistic risk assessment of the N reactor is needed, to ensure that the N operators and safety management focus comprehensively on the malfunctions, possible failures of equipment and operators, and sequences of events that could give rise to probable low-consequence accidents and to the severe core-damage accidents that will challenge the containment. A thorough and concentrated analysis, involving the N safety managers and designers as well as independent outside groups, would be preferable to the two parallel assessments now underway.

The earliest date now estimated for completing the probabilistic risk assessment is about one year from now. The probabilistic risk assessment is important, but it should not interfere with the more immediate attention that must be given to the issues outlined above.

10. THE MANAGEMENT OF NUCLEAR SAFETY

Complacency by operators, managers, and infrastructure, engendered by many years of successful operation and by the belief that the unexpected cannot happen, appears to have been a root cause of the Chernobyl accident, it was a major contributor to the Three Mile Island accident, and it is a central issue in the management of nuclear safety at any reactor. Complacency is now challenged at commercial reactors by the Nuclear Regulatory Commission's Licensing Event Reports; the Institute of Nuclear Power Operation's (INPO's) systematic and frequent communication of operating experiences at other reactors; implementation of INPO's standards of good practice; INPO's audits of review and audits of training, operations, emergency response, and management; and by the periodic inspections by the Nuclear Regulatory Commission.

The N reactor is operated by a competent organization and is monitored by competent groups within the Department of Energy. However, the N reactor suffers from being a one-of-a-kind reactor, without the direct benefits of maturing and evolving safety technology and practices that accompany the multiple and continuing analyses and review of the commercial reactors. The N safety infrastructure does not provide the extensive technical communication on safety issues that results from NRC- and INPO-stimulated communication on safety issues and operating experiences from commercial reactors. The N-reactor design is unique, but the practices of operation and management essential to ensure nuclear safety are not. Safety management of the N reactor would benefit greatly by full participation with INPO and its commercial and foreign members.

INPO audits are conducted by experienced teams expert in the practices of managing nuclear safety, expert in making effective audits, and up to date on the experiences and technical problems at other plants. The automated SEE-IN information exchange and communications managed by INPO is used by all commercial reactor operators in this country and by many foreign countries. INPO audits of all phases of N-reactor operation and safety management, accreditation of N-reactor training by the National Academy for Nuclear Training, and participation in the INPO communications system by the N-reactor operators and management are recommended.

11. FINDINGS

Based on the analysis and discussion presented in this report, the following findings are reached:

1. Have all key technical questions and potential safety issues been

considered?

Technical questions and potential safety issues have been considered comprehensively by the UNC Nuclear Industries and by the Department of Energy's safety review teams. Further investigation needs to be carried out in several areas, as outlined herein, as well as in areas identified in the reports from the review teams.

2. Have relevant facts and findings from the Soviet accident been addressed by the review teams?

The Department of Energy review teams have addressed comprehensively the relevant facts and findings of the Chernobyl accident that are now available. The analysis presented in this report questions some of the N-reactor conclusions and recommendations by the review teams and it calls for higher priority and more immediate action on confinement issues.

3. Is the N reactor being operated safely?

The N reactor is being operated competently and with good safety practices, although some, such as the maintenance of the on-line sampling system, do not measure up to the practices now set for the commercial reactor industry. The N reactor does not now operate within the risk level concluded in the 1978 safety study because of:

1. technical uncertainty in the production of hydrogen in severe accidents,

2. doubt that the hydrogen will be so rapidly mixed within the confinement compartments that hydrogen burning cannot occur,

3. the need to install ignitors or to inert the confinement to prevent hydrogen explosion,

4. technical uncertainties in the design of the confinement fog sprays to remove radioactivity released to the confinement, and

5. risk of contaminating ground and surface water from radioactive liquids produced in a severe accident and pumped to a crib outside the confinement.

The N reactor has not kept pace with some of the evolving safety requirements and practices of the commercial reactor industry, and it does not operate within the risk level implied by those requirements.

The Department of Energy should determine what N-reactor safety standards and risks are justified by the benefits from its operation.

4. Can the N reactor be operated safely?

The N reactor can be operated within the risk levels found in the 1978 safety analysis report if the uncertainties in that report, as identified herein, are resolved. The report concludes that hydrogen will not burn in the confinement and that the fog spray will quench the steam and remove radioactivity released to the confinement. An adequate technical basis for that conclusion has not been established for the N reactor.

The N reactor can be operated within the safety standards of the commercial reactor industry, but it will require considerable extensions of the safety analysis, modifications to plant and procedures, and participation in the communication and audit process of the commercial reactor industry.

The Department of Energy should determine if the tighter safety standards of the commercial reactor industry are justified for the N reactor.

12. RECOMMENDATIONS

Based on these lessons and on the evaluation discussed later in this report, the following principal recommendations are made:

1. The Department of Energy should determine the standards for risk and safety for the N reactor that are justified by the benefits from operating that reactor.

2. Resolve the uncertainties in performacce of the N-reactor confinement system.

3. Install a hydrogen-mitigation system for the N-reactor confinement. Calculate the local concentrations of hydrogen in confinement compartments during an accident, including the effects of larger amounts and rates of hydrogen release and including different locations of the release, to aid in designing the hydrogen-mitigation system.

4. Install a confined basin or tank to contain highly radioactive liquids that will be pumped from the confinement during an accident.

5. Update the safety analysis of the chemical form and amounts of fission products that will be evolved from overheated fuel.

6. Extend the safety analyses to include accidents that can develop higher fuel temperatures, generate greater quantities of hydrogen at greater rates, and evolve fission products in different chemical forms, including accidents involving equipment failure and operator error.

7. Analyze the performance of the radioactivity removal system in the N confinement, to include:

(a) the different chemical and physical forms of radioactivity that can be released to the confinement under accident conditions,
(b) a technical basis for the particle-size distribution of particulate radioactivity released to the confinement and transported to other compartments,
(d) a mass transfer analysis that does not rely on data on radioactivity-removal kinetics obtained when there is simultaneous condensation of steam, and
(e) an analytical technique that has been verified and validated, including verification with data on multicompartment removal systems and validation of assumptions of gas and liquid flow and mass-transfer kinetics.

8. Develop realistic predictions of confinement performance symptoms, e.g., time-dependent pressure, temperature, species and radioactivity concentrations to be used in training confinement operators and in developing emergency procedures to mitigate possible confinement malfunctions during accidents.

9. The N-reactor operating organization should become an active information-sharing participant with the Institute of Nuclear Power Operations (INPO), should implement the safety management practices established for the commercial reactor industry, should be audited periodically by INPO, and should have its training program accredited by the National Academy of Nuclear Training.

The above recommendations should be implemented in the near future and should not wait the completion of the probabilistic risk assessments of the N reactor that will take at least a year.

10. The Department of Energy should sponsor thorough technical analyses to better understand the details of the reactor transients involved in the Chernobyl accident and to verify the ability to calculate such transients.

13. ACKNOWLEDGMENTS

In developing the information base for this report, I am grateful for the help and cooperation from the many people and organizations who went out of their way to provide data and who shared information in early draft form as soon as it was available. The staff support of Marilyn Smith, John Ireland, and Glenn Graves was especially helpful. Individuals at UNC Nuclear Industries have been most cooperative in supplying information and making calculations to help clarify technical issues. Individuals at the Oak Ridge National Laboratory were helpful in discussing radioactivity releases from overheated fuel and in sharing their technical analyses of the Chernobyl accident.

14. REFERENCES

1. J. L. Herrington, Secretary, U. S. Department of Energy, May 7 1986.

2. United Nuclear Corporation, "N-Reactor Updated Safety Analysis Report," Report UNI-M-90, February 1978.

3. USSR State Committee on the Utilization of Atomic Energy, "The Accident at the Chernobyl Nuclear Power Plant and Its Consequences," Information Compiled for the IAEA Experts Meeting, August 25-29, 1986, Vienna, Austria (August 1986).

4. V. I. Pushkarev, et al., "Ways of Altering the Coefficients of Reactivity in RBMK Reactors," Atomnaya Energiya 46 (6), 386-389 (1979) (translation).

5. T. G. Schleiter, et al., "Design Review of the N Reactor," U. S. Department of Energy, September 1986.

6. W. J. Quapp, UNC Nuclear Industries, Private Communication, September 12 and October 2, 1986.

7. J. R. Travis, "HMS: A Computer Program for Transient, 3-D Mixing of Gases," Los Alamos National Laboratory Report LA-10267-MS, NUREG/CR-4020, 1985.

8. A. A. Amsden, J. D. Ramshaw, P. J. O'Rourke, J. K. Dukowicz, "KIVA: A Computer Program for Two- and Three-Dimensional Fluid Flows with Chemical Reactions and Fuel Sprays," Los Alamos National Laboratory report LA-10245-MS (1985).

9. L. H. Roddis, Jr., Chairman, Panel of Expert Consultants, Letter to A. W. Trivelpiece, U. S. Department of Energy, July 18, 1986.

10. P. C. Owzarski, "Corral Code Analysis of Airborne Fission Product Behavior Following Postulated N Reactor Accidents," United Nuclear Industries Report UNI-NUSAR-14, June 1979.

11. R. K. Hilliard, A. K. Postma, J. D. McCormack, and L. F. Coleman, "Removal of Iodine and Particles by Sprays in the Containment Systems Experiment," Nuclear Technology, 10, 499-519, April 1971.

12. T. K. Sherwood, R. L. Pigford, C. R. Wilke, "Mass Transfer," p. 231, McGraw Hill, New York (1975).

13. G. W. Parker, G. E. Creek, C. J. Barton, W. J. Martin, R. A. Lorenz, "Out-of-Pile Studies of Fission-Product Release from Overheated Reactor Fuels at ORNL, 1955-1965", Report ORNL-3381, 1967.

14. United States Nuclear Regulatory Commission, "Technical Bases for Estimating Fission Product Behavior During LWR Accidents," Report NUREG-0772, June 1981.

APPENDIX A.

Questions to the U.S. Department of Energy on the Chernobyl Accident
June 18, 1986

1. What event(s) caused the transient from 7 to 50 percent power, and what events caused release of hydrogen and fission products?

2. Is it correct that there was no loss of offsite power?

3. If a single pressure-tube channel is completely voided, is the net reactivity change from a water-filled channel or a channel in normal operating conditions positive or negative?

4. Can loss of coolant to one process tube cause reactivity changes or flow changes that result in loss of coolant to an adjacent process tube?

5. Soviet technical reports describe concrete-walled rooms near the reactor that contain the header and steam separator, to which the process tubes or connected. The room is designed to contain an overpressure of about 27 psi. Does this 27-psi envelope extend under the working floor that is immediately above the reactor?

6. Are the cavities designed for 27 psi and others for 52 psi lined with metal or with other material to result in a low leak rate of gases from the cavities?

7. Are noncondensable gases that evolve from the pressure-suppression pools contained in the suppression-pool cavities? If not, where do they vent?

8. What is the design pressure of the pressure-suppression pool cavities?

9. What gas normally exists between the top of the reactor and the bottom of the working floor above the reactor?

10. Is the reactor designed to withstand the failure of a pressure tube, thereby allowing water and steam to discharge directly into the surrounding graphite?

11. Had any provision been made for handling hydrogen generated by zirconium-water reaction?

12. Was spatial instability of neutron flux involved in this accident sequence? If so, was it axial instability or azimuthal instability?

13. What are the failure pressures of the compartments described above?

APPENDIX B

Comparison of RBMK-1000 (Chernobyl Unit 4) and N Reactor Design

(Supplied by the Pacific Northwest Laboratory)

Design Characteristics	RBMK-1000	N Reactor	Remarks
Reactor type	Vertical pressure tube-boiling water-graphite moderated	Horizontal pressure tube-pressurized water-graphite moderated	The vertical arrangement, boiling water concept is a basic contrast to the horizontal arrangement pressurized water concept
Refueling	On-line	During shut-down	
Design power generation - MWt	3140	4000	The on-line refueling is inherently a higher risk operation than refueling while not operating.
Electrical Power generation-MWe	1000	860	
Inlet temperature (avg.)	270°C (518°F)	400°F	
Outlet temperature (avg.)	284°C (543°F)	543°F	
Operating pressure (outlet)	70.21 kg/cm^2 (1000 psi)	1600 psi	
Total reactor coolant flowrate	42,000 t/h (76.2x10^6 lb/h)	83.2 x 10^6 lb/h	

Comparison of RBMK-1000 (Chernobyl Unit 4) and N Reactor Design

Core Description	RBMK-1000	N Reactor	Remarks
Core dimensions (active zone):			The RBMK has a positive void coefficient in contrast to a negative void coefficient at N reactor
Height	7.0 m (275.6 in.)	302 in.	
Diameter or width	11.8 m (464.6 in.) Dia.	303 in. width	
Length		418 in.	
Volume	765.5 m^3 (46.71x10^{6}in^3)	38.25 x 10^6 in^3	
Total number of fuel channels	1661	1003	
Lattice spacing	250 mm x 250 mm (9.8 in. x 9.8 in.)	9 in. vertical x 8 in. horizontal	
Moderator material	Graphite	Graphite	
Operating temperature (maximum)	750°C	600°C	
Material density (theoretical)	1.67-1.73 g/cm^3	1.71 g/cm^3	
Material density (as stacked)	1.31-1.36 g/cm^3	1.29 g/cm^3	
Moderator weight	976 mt (1.076 t)	900 t	
Reflector Dimensions:			
top and bottom	500 mm (19.69 in.)	48 in.	
sides	1000 mm (39.37 in.)	44 in.	
front and rear		20 in.	

Comparison of RBMK-1000 (Chernobyl Unit 4) and N Reactor Design

Fuel	RBMK-1000	N Reactor	Remarks
Design	Two 18 rod elements connected in series	Multiple uranium tube-in-tube	
Uranium form	UO_2	Metallic	
Cladding material	Zr-1% Nb	Zr-2	
Enrichment wt% ^{235}U	2.0	0.71-1.25	This combined with the greater graphite temperature and steam water coolant state of the RBMK increases the risk further
Fuel assembly length	7.0 m (22.95 ft.)	34.8 ft.	
Maximum clad temperature	323°C (613°F)	583°F	
Maximum fuel temperature	1,800°C (3272°F)	807°F	
Total fuel weight	186 mt	366 mt	
Fuel exposure	18.5-22.3 GWd/t (18,400-22,300 MWD/MTU)	440-1980 MWD/MTU	
Maximum Thermal Flux	83 W/cm^2 (263,325 $BTU/hr\text{-}ft^2$)	385,660 $BTU/hr\text{-}ft^2$	

Comparison of RBMK-1000 (Chernobyl Unit 4) and N Reactor Design

Fuel Channel	RBMK-1000	N Reactor	Remarks
Number	1661	1003	To provide the 14.5% average steam quality the flow to the individual fuel channels of the RBMK-1000 are manually reset 2 or 3 times during the fuel cycle. The N reactor allows no flow adjustments
Pressure tube diameter (OD)	8.8 cm (3.46 in.)	3.26 in.	
Pressure tube wall thickness	0.4 cm(0.158 in.)	0.275 in.	
Material	Zr-2.5% Nb	Zr-2	
Termination method	Diffusion welded Zr to SS joint in reactor core zone	Rolled Zr to CS joint out of reactor	
Individual channel flow control	Manually adjusted regulating valve	Orifice installation at outer fringe tubes	
Inlet temperature	270°C (518°F)	400°F	
Outlet temperature (avg)	284°C (543°F)	543°F	
Quality	14.5% avg. steam	subcooled	
Average tube power	1890 KWt	4000 KWt	
Average tube flow rate	45.01×10^3 lb/h	83.35×10^3 lb/h	
Axial peak/avg. power ratio	1.26-1.33	1.40	
Radial peak/avg. power ratio	1.27-1.40	1.25	

Comparison of RBMK-1000 (Chernobyl Unit 4) and N Reactor Design

Control-Shutdown System	RBMK-1000	N Reactor	Remarks
Type	Boron steel segments encased in aluminum, lowered by gravity and retreived by servo-mechanisms from above through a cable.	Boron carbide encased in titanium, driven by pressurized accumulators horizontally into the reactor.	The N Reactor control-safety rods are fully inserted in 1/8 the time required for the RBMK rods. The horizontal arrangement, in contrast to the vertical arrangement, is not prone to be ejected during an accident or drive failure
Number of control-shutdown assemblies	211	84	
Neutron absorption material	Boron steel	Boron in B_4C	
Control rod spacing	500 mm x 500 mm (19.7 in. x 19.7 in.)	32 in. horiz. 36 in. vert.	
Control rod travel	6.25 m (20.5 ft.) except auto. control rod - 4.5 m (14.8 ft.) & axial control rod - 7.0 m (23 ft.)	29.5 ft.	
Cooling method	Separate water cooling system with downward flow in individual channels	Integral water cooling jackets	
Drive	Gravity	Hydraulic (with accumulators)	
Control rod full insertion time	20 seconds	2.5 seconds	

Comparison of RBMK-1000 (Chernobyl Unit 4) and N Reactor Design

Safety shutdown system	RBMK-1000	N Reactor	Remarks
Type	Same as control-shutdown rod assemblies	Boron in boron oxide balls contained in hoppers above individual moderator channels. Release is spring loaded and held by electromagnetics system in a "fail safe" manner	The N reactor safety shutdown system is based on a different principle and is independent of the control-shutdown system
Number of safety shutdown assemblies	21	107	
Neutron absorption material	Boron steel	Boron in B_4C	
Drive	Gravity	Gravity	
Minimum shutdown margin		19.0-20.9 mk (1.0 mk margin with failure of 5 strongest ball hoppers)	

Comparison of RBMK-1000 (Chernobyl Unit 4) and N Reactor Design

Primary Water Recirculation	RBMK-1000	N Reactor	Remarks
System material	Austenitic stainless steel	Carbon steel	The 2 independent primary loops and in-reactor boiling of the RBMK-1000 reactor coolant provides a more difficult nuclear control problem than the N reactor single loop pressurized water concept
Total flow rate	42,000 t/h (76.2 x 10^6 lb/h	83.2 x 10^6 lb/h	
Equipment cells	2	6	
Independent flow loops	2	1	
Steam separators (total/per loop)	4/2	none	
Steam heat exchangers (total/normally operating)	none	12/10	
Pumps (total/normally operating)	8/6	6/5	
Pump dynamic head	2.0 MPa (669 ft, H_2O)	804 ft, H_2O	
Dimensions of individual inlet piping (OD x wall)	5.7 x 0.35 cm (2.244 in. x .158 in.)	2.625 in. x 0.260 in.	
Dimensions of individual outlet piping (OD x wall)	7.6 x 0.4 cm (2.992 in. x .158 in.)	2.625 in. x 0.260 in.	

Comparison of RBMK-1000 (Chernobyl Unit 4) and N Reactor Design

Steam Secondary System	RBMK-1000	N Reactor	Remarks
Steam collector type	Primary system steam separators	Tube type heat exchangers	The N reactor steam generators provide a pressure-retaining barrier between the reactor primary coolant and the secondary steam. The RBMK-1000 boils the primary coolant in the reactor and uses this steam directly for power generation
Number	4/2 (total/per loop)	12/10 (total/ normally operating)	
Collector (ID x Length)	2.6 x 30 m (8.53 x 98.4 ft.)	10 x 57 ft.	
Steam pressure	6.86 MPa (995 psia)	150 psia	
Steam flowrate (total)	5.468 t/h (12 x 10^6 lb/h)	13 x 0^6 lb/h	
Power generation	1000 MWe	860 MWe	
Heat rejection w/o turbogenerators	Water reservoir	16-dump condenser heat exchangers	

Comparison of RBMK-1000 (Chernobyl Unit 4) and N Reactor Design

Release Control	RBMK-1000	N Reactor	Remarks
Type	Partial steam suppression of releases from the reactor cavity, inlet piping and pumps	Confinement system employing initial steam release followed by high efficiency filtration of releases	The RBMK-1000 doesn't have a confinement system. The upper portion of the reactor, outlet piping and steam separators have no substantial enclosure. Steam from the reactor is directed out into the machinery bay which is housed in a standard industrial building
Enclosure	Lower half of reactor and lower half of piping system.	Entire reactor, coolant system and reactor gas system	
Function	Condense steam from piping break or steam separator relief valves.	Confine radionuclides from the reactor and potentially contaminated piping systems.	Off-gases from the steam supression pool below the reactor is released into the upper reactor area when relief valve settings are exceeded.
Design pressure	Enclosure areas designated about 0.4 MPa (58 psi)	+5.0 psig to -2.0 psig.	
Operation	Steam -water from pipe break or steam separator relief valves directed to standing water in bubbler pond below reactor. Water spray above bubbler pond helps condensation process.	Vent valves release initial steam - surge following pipe break. Fog spray system control confinement pressure to near atmospheric. Filter system to remove 99.95% of particulates and 93% elemental radiohalogens.	